Bedford Institute of Oceanography

2003

Canada

Change of address notices, requests for copies, and other correspondence regarding this publication should be sent to:

The Editor, BIO 2003 in Review
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

E-mail address: ryanje@mar.dfo-mpo.gc.ca

Cover painting of the Bedford Institute of Oceanography: copyright of the painter, Anne Duggan, reproduced courtesy of Ms. Duggan and the Bedford Institute of Oceanography.

Anne Duggan is an award-winning water-colourist who lives in Sackville, Nova Scotia. Anne has multiple sclerosis and from her wheelchair expresses her feelings through painting. Her soft, fluid pastels create a sense of calm and contentment, while vibrant splashes of colour convey energy and excitement. Her greatest triumphs come when her paintings evoke special feelings. Many of her commissioned watercolours hang as memorials in Maritime hospitals, while her work is owned also by corporate and academic institutions and individual collectors from around the world. Notable amongst her published work is Grand Pré Rose Garden, which graces the first cover in the Remember When book series. Active in the art world, Anne is a leader in several local associations, frequently teaches and leads workshops, and exhibits at regional galleries.

© Her Majesty the Queen in Right of Canada, 2004-06-08

Cat. No. Fs75-104/2003E
ISBN: 0-662-35362-5
ISSN: 1499-9951

Aussi disponible en français

Editors: Dianne Geddes and Judith Ryan **Editorial team:** Pat Dennis, Karen Rutherford, and Bob St-Laurent

Design:
Channel Communications, Halifax, Nova Scotia

Photographs:
BIO Technographics, the authors, and individuals/agencies credited

Published by:
Fisheries and Oceans Canada and Natural Resources Canada
Bedford Institute of Oceanography
1 Challenger Drive
P.O. Box 1006
Dartmouth, Nova Scotia
Canada B2Y 4A2

BIO website address: www.bio.gc.ca

Introduction

The Bedford Institute of Oceanography (BIO) is a major oceanographic research facility, established in 1962 by the Government of Canada and located on the shores of the Bedford Basin in Dartmouth, Nova Scotia. Over the last four decades it has grown to become Canada's largest centre for ocean research. Scientists at BIO perform targeted research, mandated by the Canadian government, to provide advice and support to government decision-making on a broad range of ocean issues including sovereignty, defence, environmental protection, health and safety, fisheries, and natural resources. They also undertake environmental planning and oceans management.

Fisheries and Oceans Canada is represented by five divisions within its Science Branch, the Canadian Hydrographic Service (CHS), two divisions of the Oceans and Environment Branch, the Aquaculture Coordination Office, and by the Canadian Coast Guard for technical and vessel support. Together they provide scientific knowledge and advice on issues related to climate, oceans, the environment, marine and diadromous fish, marine mammals, shellfish, and marine plants. As well, they carry out oceans and environmental management and planning.

Natural Resources Canada is represented by the Geological Survey of Canada (GSC) -Atlantic, Canada's principal marine geoscience facility. Its scientific research expertise focuses on marine and petroleum geology, geophysics, geochemistry, and geotechnology. GSC Atlantic is also the source of integrated knowledge and advice on Canada's coastal and offshore landmass.

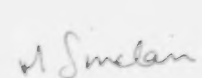
National Defence Canada (DND's) Route Survey Office of Maritime Forces Atlantic, located at BIO, supports ocean surveillance activities. Surveys are conducted in areas of the sea floor of specific interest to DND, in cooperation with CHS and GSC Atlantic.

In support of the Canadian Shellfish Sanitation Program, the Shellfish Section of Environment Canada conducts sanitary and water quality surveys and analyzes the samples at the microbiology laboratory at BIO.

Altogether, approximately 650 scientists, engineers, technicians, managers, support staff, contractors, and others from a variety of disciplines, work at BIO.

This review highlights some of the ongoing research activities at the Institute as well as some of the activities dealing with the management of the oceans.

Jacob Verhoef
Director, Geological Survey of Canada-Atlantic
Natural Resources Canada



Michael Sinclair
Director, BIO and Regional Director, Science
Fisheries and Oceans Canada

Faith Scattolon
Regional Director
Oceans and Environment
Fisheries and Oceans Canada

Contents

RETROSPECTIVE 2003 4

SCIENCE ACTIVITIES

Atlantic Seal Research Program: Grey Seal Predation in Continental Shelf Ecosystems 16
– Don Bowen and Jim McMillan

Live Gene Banking of Endangered Populations of inner Bay of Fundy Atlantic Salmon 18
– Patrick G Reid

Marine Plants Research: Diverse Needs in the 21st Century 20
– Glen Sharp and Rick Semple

BIO Research on Deep-Water Corals in Atlantic Canada 22
– Ellen K. Kenchington, Cynthia Bourbonnais and Kevin G. MacIsaac

Contaminated Harbours 24
– Bill Dale and Ken Lee

Working Together to Identify and Protect Maritime Coastal Habitats for Future Generations 26
– Dave Duggan

Nature's Silly Putty: 200 Million Years of Salt Deformation and Sediment Deposition 27
– John Shimeld

North Atlantic Circulation Modelling 30
– Dan Wright, Kevin G. Hall Yashayaev, Alain Vézina, and Svetlana Loktionov

Novel Technology for Profiling near the Surface under Arctic Ice: The Icycler 32
– George Fowler

BIO SCIENCE IN PARTNERSHIP

State of the Ecosystem Report for the Eastern Scotian Shelf 34
– Kenneth Frank, Ken Drinkwater, Glen Harrison, Brian Petrie, Phil Smith, Alida Bundy, Heather Breeze, Jane Collie, Simon Kraan, Kristen Quasbarth, Robert O'Boyle, and Joe Choi

A River Worth Saving: The Installation of a Bottom Draw Siphon on the St. Francis Harbour River 37
– Ron MacGregor with Doreen Hiltz

Validation of Sea-Ice Properties in Satellite Imager 38
– Ingrid Peterson, Simon Prinsenberg, Scott Holladay, and Luis Hamilton

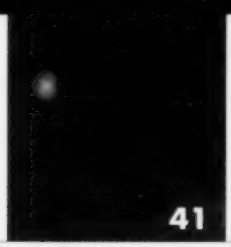
Coastal Remote Sensing Applications in Canada's Western Arctic 40
– Dustin Marson, Steve Solomon, Donald Forbes, Jason Lee, Ian Sonden, and Curtis Rainnie

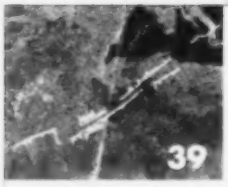
Canada and USA Fishermen Collaborate on Lobster Recruitment Research 42
– Barry Kling, Patricia Pinsky, Carl MacDonald, and Shannon Scott-Denton

Assessing Potential Impacts of Seismic Activity on Northern Bottlenose Whales in the proposed Gully Marine Protected Area 44
– Kenneth Lee and Rosalie Allen Jarvis

Onshore Geoscience in Nova Scotia: The Targeted Geoscience Initiative in Southwestern Cape Breton Island 46
– Peter Giles

Offshore Oil and Gas Environmental Effects Monitoring Workshop: Approaches and Technologies 48
– Shelley Armsworthy, Peter Cranford, Kenneth Lee, and Rosalie Allen Jarvis





SUPPORT HIGHLIGHTS

Research Voyages in 2003 49
– Donald Bellveau

CCGS *Matthew* Sails into the 21st Century 50
– Michael Lamplugh

Remaking the Major Facilities at BIO 52
– Mark Christian

SPECIAL PROGRAMS

The Partnership for Observations of the Global Oceans 53
– Shubha Sathyendranath

The BIO Hypatia Project Influences National Initiatives 54
– Sherry Nilsen

BIO: WITHIN OUR COMMUNITIES

BIO Outreach 2003 56
– Joni Henderson and Jennifer Bates

Community Assistance in 2003 59
– Andrew Stewart and Maureen MacDonald

The BIO-Oceans Association:
Actions and Accomplishments in 2003 60
– David Nettleship

FINANCIAL AND HUMAN RESOURCES

Financial Information 62

People at BIO in 2003 64

PUBLICATIONS AND PRODUCTS

Publications 2003 72

Products 2003 89

Retrospective 2003

On September 29, Hurricane Juan made a direct and brutal hit on the Halifax Regional Municipality, then proceeded to cut a swath of destruction north through Nova Scotia and Prince Edward Island. Damage caused by the high winds and uprooted trees created havoc in transportation and electrical power transmission. Fortunately, injury to the Bedford Institute of Oceanography (BIO) campus was minor, but the facility was closed for six working days due to a downed power pole.

The emergency brought out the best in BIO staff. During the difficult post-hurricane period, the Route Survey Office (the small National Defence contingent) worked on the clean-up of the grounds. The Fisheries and Oceans Canada (DFO) Technology Services Division did an excellent job sustaining their informatics system. Commissionaires and Public Works and Government Services Canada employees calmly and competently maintained the buildings and their security. Natural Resources Canada (NRCan) staff had spent two years organizing an international conference to start September 30 and run for that week. Due to the quick-witted resourcefulness and efficiency of employees from NRCan and DFO, the International Conference on Arctic Margins went ahead, and was universally considered to have been a huge success.

Throughout 2003, scientists at BIO engaged in ongoing research as well as undertaking several new and innovative initiatives. Many of these activities are described in articles. Other highlights at BIO are featured, in this *Retrospective*.

Dartmouth, after Hurricane Juan – photos by Francis Kelly

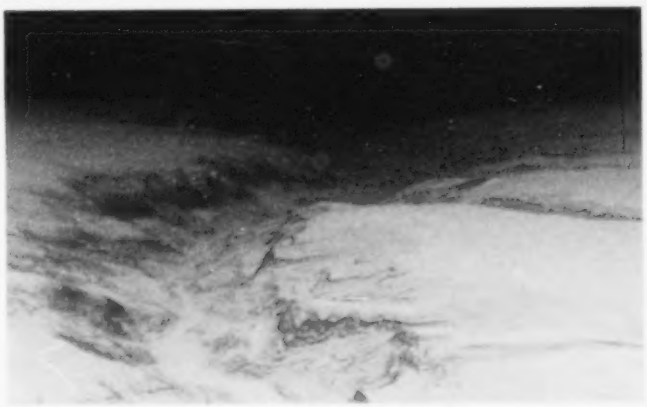
Erosion and damage at Lawrencetown Beach caused by Hurricane Juan – photo by Bob Taylor

HIGHLIGHTS AND NEW INITIATIVES

In November, Canada became the 144th country to ratify the **United Nations Convention on the Law of the Sea (UNCLOS)**. UNCLOS provides the framework for international oceans law, governing many aspects of oceans affairs including fisheries, navigation, marine pollution, and scientific research. Ratification allows Canada to enjoy the benefits of UNCLOS, including acquisition of the means to delimit the outer edge of its continental shelf. Canada will also gain a voice in UNCLOS institutions, such as the International Seabed Authority, and will be able to participate in decisions of importance to Canada. NRCan and DFO will have important roles to play in furthering Canada's UNCLOS participation.

The proposed regulations and accompanying Regulatory Impact Analysis Statement (RIAS) to designate **The Gully a Marine Protected Area (MPA)** under the *Oceans Act* were published in the *Canada Gazette Part I* (Vol. 137, No. 49) on December 6, 2003. The Honourable Robert Thibault, Minister of Fisheries and Oceans, announced the launch of the final 30-day public comment period on the MPA at BIO on December 8, 2003. Coordinated by the Maritimes Region Oceans and Coastal Management Division (OCMD) and DFO Headquarters, this official public consultation phase provided a final opportunity to comment on the regulations before enactment and publication in the *Canada Gazette Part II*.

The State of the Ecosystem for the Eastern Scotian Shelf report was published. This innovative report provides a synthesis of oceanographic, ecological, and ocean use trends over several decades. It provides the background information for the development of an integrated management plan to harmonize conduct of different ocean uses such as fishing, oil and gas developments, and transportation. The results of the report were presented at international and national meetings. (*See* article: *State of the Ecosystem Report for the Eastern Scotian Shelf.*)



The Gully

105-01489/

Distribution of captive-reared adult inner Bay of Fundy (iBoF) salmon to the Point Wolfe River, New Brunswick
Helicopter approaches Lower Oxbow pool release site with tub of iBoF salmon from the Mactaquac living gene bank. The group, representing five collaborating agencies, discusses the release of the fish from the tub, left to right: Jane Watts (Fundy National Park), Jonathan Carr (Atlantic Salmon Federation), Jason Flanagan (DFO Salmon Assessment), Tim Robinson (Fort Folly First Nation), and Rod Price (DFO Mactaquac Biodiversity Facility). iboF salmon swim out of the tub: the fish with white discs carry acoustic (pinger) tracking tags.
– Parks Canada photos

DFO's **Diadromous Fish Division's Mactaquac Biodiversity Facility** saw several partnerships come to fruition in 2003. Joint projects with the State of Maine and Atlantic Salmon for Northern Maine saw the first delivery of Atlantic salmon eggs from captive-reared Tobique (tributary of the Saint John River, New Brunswick) adults, for eventual partner release to the Aroostook tributary (Saint John River, Maine). Scheduled Live Gene Bank rearing of endangered Upper Salmon River juvenile salmon for Fundy National Park led to a Parks Canada initiative to examine the utility through acoustic tracking of these Mactaquac captive-reared Big Salmon River adults released to the Point Wolfe River, New Brunswick.

A national plan on marine biodiversity was developed from the deliberations arising from a national workshop and follow-up meetings. The plan, entitled ***Three Oceans of Biodiversity, A Canadian National Plan 2004-2009***, provides guidance on inventory, monitoring, and research on marine biodiversity in support of Canada's commitment to the Convention on Biological Diversity.

The **Marine Fish Division (MFD)** has, as part of the DFO **Geoconnections Program,** taken the lead in development of **an integrated taxonomic information system for BIO.** It has been used to develop an authoritative species list for the MFD trawl survey and ichthyoplankton data sets. The system will be useful also in validating scientific names against internationally accepted standards and in the provision of full taxonomic hierarchies. It provides information to create direct links to web-based systems such as Fishbase. Potentially, the system could serve as an authoritative base for the

species code portion of the national Common Language Management System.

The MFD has developed an **electronic atlas for ichthyoplankton on the Scotian Shelf of North America (EAISSNA)**. The EAISSNA database contains authoritative information on location and time of spawning, and abundance and distribution of eggs and larvae of marine fish on the Scotian Shelf, and it is intended for use in environmental assessment and management activities associated with offshore hydrocarbon development and production and ocean management.

A joint industry-DFO **research study of spiny dogfish in Atlantic Canada** has been started to better understand the biology, movements, and population health of this abundant small shark species. With the partial closure of the American dogfish fishery, there was concern that the Canadian dogfish population also may be at risk. Final results are expected in 2007.

The **Ocean Sciences Division (OSD)** is collaborating with Dalhousie University and Environment Canada in a new three-year project on **Interdisciplinary Marine Environmental Prediction in the Atlantic Coastal Region,** funded in part through the Canadian Foundation for Climate and Atmospheric Sciences. The project involves an atmosphere-ocean observing system in Lunenburg Bay, and predictive models for the atmosphere, ocean circulation and biology, and waves.

The OSD is collaborating in two new programs related to improved **observation and prediction of marine winds and waves**. One is a joint initiative with Environment Canada, NRCan, the National Research Council, Defence Research and Development Canada, and Dalhousie and McGill universities, to collect and analyze offshore wind and wave data during extra-tropical storms, in order to help improve their forecasting. The second program is a joint initiative with Environment Canada, partly funded by the Canadian Space Agency, to develop methodologies for estimating marine wind fields from two types of satellite radar data, for use in validating numerical weather prediction models.

Fifteen autonomous floats for profiling the ocean were deployed in the Labrador Sea and western North Atlantic, completing the three-year deployment of floats under the **international Argo program.** A total of 78 floats supplied by Canada, France, Germany, the United Kingdom, and United States are returning a temperature/salinity profile down to 2000 m every ten days, to an international data centre and various ocean modelling groups.

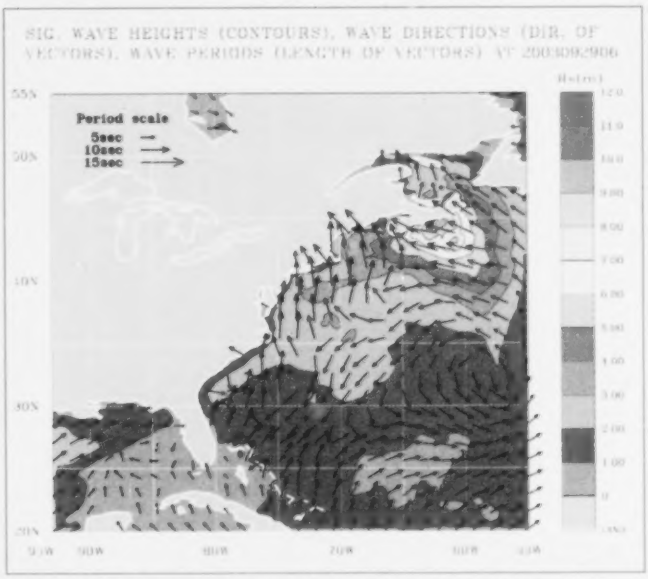
The OSD is participating in an interdepartmental initiative to develop a **Federal Climate Change Science Plan.** Environment Canada is the lead department on this project intended to lay out a common, integrated approach for all federal departments and agencies involved in climate change science to ensure that the Canadian Government has the knowledge and tools to make informed policy and program decisions on climate change actions. The stakeholder-based plan will cover science activities to be undertaken by the federal government over the next five years, but also provide a longer-term outlook.

A complementary interdepartmental planning exercise with OSD participation is connected to **an international initiative by** the *ad hoc* **Group on Earth Observations (GEO) to develop a global observing system**. DFO's primary contributions to this project lie in determining the appropriate scales and accuracies of ocean measurements required for management of marine ecosystems, the prevention or mitigation of marine hazards and disasters, and the monitoring of ocean climate. As with the Federal Climate Change Science Plan, Canadian GEO is strongly driven by stakeholders, clients, and the Canadian public.

The **mapping of the Bras d'Or Lakes** has generated public and stakeholder interest since a wealth of previously undetected phenomena were revealed, including large areas of sink holes, ancient coastlines, and rivers that were submerged by the rising sea level. A team from the **Geological Survey of Canada of NRCan** has identified that the lakes were transformed into an inland sea about 5,000 years ago.

The December 2002 issue of the *Proceedings of the Nova Scotian Institute of Science* came out in early 2003. This special issue dealt exclusively with **the oceanography of the Bras d'Or Lakes,**

SIG. WAVE HEIGHTS (CONTOURS), WAVE DIRECTIONS (DIR. OF VECTORS), WAVE PERIODS (LENGTH OF VECTORS) VT 2003092900
Period scale
5sec
10sec
15sec


SIG. WAVE HEIGHTS (CONTOURS), WAVE DIRECTIONS (DIR. OF VECTORS), WAVE PERIODS (LENGTH OF VECTORS) VT 2003092906
Period scale
5sec
10sec
15sec

Hurricane Juan, a category 2 hurricane that propagated northward through Atlantic Canada on September 29, provided the first real-time test of state-of-the art, high resolution wave models for the Northwest Atlantic. Figures show BIO wave model outputs for 12-h and 18-h forecasts valid for 00 UTC (Coordinated Universal Time) and 06 UTC for the NW Atlantic along the storm track of Juan.

providing a comprehensive synthesis of existing scientific information. The content was provided by both NRCan and DFO scientists at BIO. The book is timely, given the focus on integrated management of this unique Cape Breton ecosystem.

The Oceans and Coastal Management Division (OCMD) co-leads, with DFO Aboriginal Affairs, the regional development and implementation of the **Aboriginal Aquatic Resource and Oceans Management (AAROM)** program, announced on October 9. The program is intended to assist Aboriginal groups acquire the capacity to successfully manage their activities around the resource and to participate more effectively in the processes used by DFO for aquatic resources and oceans management. In 2003, information sessions with various First Nations organizations took place. The **Unama'ki Institute of Natural Resources (UINR),** representing the five Cape Breton First Nations bands, has been involved in developing, with a number of DFO sectors, **a management plan for the Bras d'Or Lakes watershed.**

A Joint Project Agreement (JPA) was made between the **Centre for Offshore Oil and Gas Environmental Research (COOGER)** and the US Environmental Protection Agency, the University of Cincinnati, and Temple University to build **an experimental wave tank facility at BIO.** The test system will have the capability to replicate physical oceanographic parameters including breaking waves, with initial studies focused on the influence of wave energy on the efficacy of chemical oil dispersants. The wave tank is expected to be fully operational in spring 2004.

NRCan's **Targeted Geoscience Initiative (TGI)**, in partnership with provincial and territorial agencies, industry, and academia, helps stimulate sustainable economic development across Canada by increasing the level and effectiveness of private sector exploration for energy and mineral resources. Initially funded for three years in 2000, TGI has been extended for two additional years. The first phase was devoted to minerals geoscience, whereas the extension will focus on energy-oriented projects.

To formalize their collaboration in the **Acoustic Monitoring and Marine Mammal Observations in The Gully and Outer Scotian Shelf Before and During an Active Seismic Program,** the Nova Scotia Department of Energy signed a Memorandum of Understanding (MOU) with COOGER. Petroleum Research Atlantic Canada also signed a Sponsorship Agreement with DFO for financial support of the project, while Marathon Canada signed a Letter of Agreement with DFO to conduct research in support of common objectives of the study, which COOGER co-ordinated. The objective of the study was to learn more about the behaviour and sound from seismic surveys and their impact on marine mammals.

A JPA with Corridor Resources Inc. supports an experiment addressing **seismic impacts on snow crabs** off the western coast of Cape Breton, Nova Scotia. The project, which was coordinated by COOGER at BIO, used Corridor's environmental effects monitoring workshop as a springboard to more fully investigate potential physical and reproductive effects in invertebrates.

A technical report was prepared on the **capacity constraints for salmon cage culture in the Fundy Isles area** of the Bay of Fundy. This multi-authored comprehensive synthesis of two decades of research provides guidance to the regulators and the aquaculture industry. Authors include DFO staff from BIO, the Biological Station in St. Andrews, and the Gulf Fisheries Centre in Moncton.

Since it was first created, the **Maritimes Regional Advisory Process (RAP)** has been a national leader in defining the peer review process for the provision of science to resource and ocean managers across the full suite of issues, and the approach has been adopted nationally. In 2003, ten **assessment meetings** were organized and convened for stocks in both the Maritimes and Gulf regions. Four additional meetings were held to review the frameworks used to conduct the annual assessments. These **Assessment Framework reviews** dealt with Southern Gulf and Georges Bank herring (the latter within the auspices of the Transboundary Resources Assessment Committee) and Scotian Shelf Pollock. The office also assisted in the planning of a Canada-US information session on spiny dogfish. Another meeting reviewed recent analyses relevant to the re-evaluation by COSEWIC (the Committee of the Status of Endangered Wildlife in Canada) of the "endangered" status of inner Bay of Fundy Atlantic salmon populations.

In 2003, as part of the celebrations marking the 90th anniversary of the launch of the retired hydrographic survey ship CSS Acadia, the Canadian Hydrographic Service partnered with the Maritime Museum of the Atlantic to create the exhibit Charting the Waters: Hydrography in Atlantic Canada. The public exhibit presents a story of Canadian hydrography: past, present, and future. One highlight of the celebration was a Crew's Reunion and Dinner, held on July 5, 2003. Former hydrographers and fellow shipmates gathered from across Canada.

The **Canadian Hydrographic Service (CHS)** is undertaking **Remote Sensing Shoreline for Northern Labrador,** a three-year project supported by the New Search and Rescue Initiatives Fund (NIF) that addresses the serious lack of up-to-date coastal information on CHS charts, particularly from Nain, Labrador north to the Button Islands. The objective is to collect shoreline information and provide it on Provisional Charts to improve Search and Rescue capability and reduce risk to mariners and the environment. The project proponents are the CHS Atlantic Region and the Surveys and Mapping Division (SMD), Department of Government Services and Lands, Newfoundland and Labrador. The aerial photography and mapping and associated project logistics are being managed by the SMD.

Junior Shorekeepers, an initiative of the OCMD, is an intertidal monitoring program that fosters environmental awareness among youth and produces data to help scientists and local communities monitor the health of coastal areas. The program teaches youth about local habitats, intertidal species, physical measurement techniques, and skills in conducting a survey. In the Maritimes Region, the first survey was completed by grade four students from the Bras d'Or Elementary School along the shores of Stewart Point, off the

Great Bras d'Or Channel, on June 9. The program will be extended to the Halifax area.

On May 10, DFO Maritimes Region and the **Atlantic Coastal Action's Program Clean Annapolis River Project** signed a JPA with the intent to work together toward conservation, stewardship, outreach, education, and management of aquatic ecosystems in the Annapolis River Watershed Area, for the benefit of present and future generations of citizens and coastal communities.

Personnel participated in the capacity-building course on integrated coastal and oceans management and governance, **Operationalizing Canada's *Oceans* Act**. This innovative collaborative professional learning experience, developed and delivered through a JPA with the Marine Affairs Program at Dalhousie University, was intended to enhance participants' problem solving skills as they sort out the significant challenges of implementing Canada's *Oceans* Act. Challenges include uncertainty of knowledge in decision-making, resolving conflicts among stakeholders, inserting accountability and precaution into the oceans management agenda, and involving civil society in policy development and management.

Staff in the **Oceans and Environment Branch (OEB)** and the **Aquaculture Coordination Office (ACO)** concluded the **Guysborough County Sustainable Aquaculture Initiative**. The overall objective was to provide Guysborough County with a comprehensive Information System Tool that would contribute to the positive and sustainable growth of their aquaculture industry. The project is now being implemented.

Throughout 2003, ACO personnel have been actively working with the provinces of Nova Scotia and New Brunswick to pursue **improvements in the marine aquaculture site review process**. The main thrust of the strategy is to harmonize information requirements and eliminate duplication of the reviewing parties at both levels of government, with the objective of expediting marine aquaculture site reviews while ensuring all concerns, including environmental, are addressed. The ACO also participated in the development of the **national policy for access to wild aquatic resources as it applies to aquaculture,** and developed a logic model and performance measurement system that links the departmental **Aquaculture Policy Framework** objectives with program delivery activities within the department.

After discussions between NRCan and the Nova Scotia Department of Education and Culture (NSDEC), ***The Last Billion Years*** was recognized as a valid teaching tool by being listed in the NSDEC Book Bureau. A copy of the book will be placed in each high school in the province. *The Last Billion Years* is a geological history of the Maritime Provinces; its publication was led by NRCan staff in collaboration with geoscience and education partners throughout the Maritimes.

The **Library** published three issues of a new electronic newsletter. *The BIO Library Newsletter* highlights many of the information resources available in the library, provides updates on the services the library currently provides, and informs library users of special projects library staff have undertaken. Also, projects have been initiated to create an online bibliography of all publications written by BIO staff and to digitize all BIO reports.

BIO WORKSHOPS AND INTERNATIONAL MEETINGS

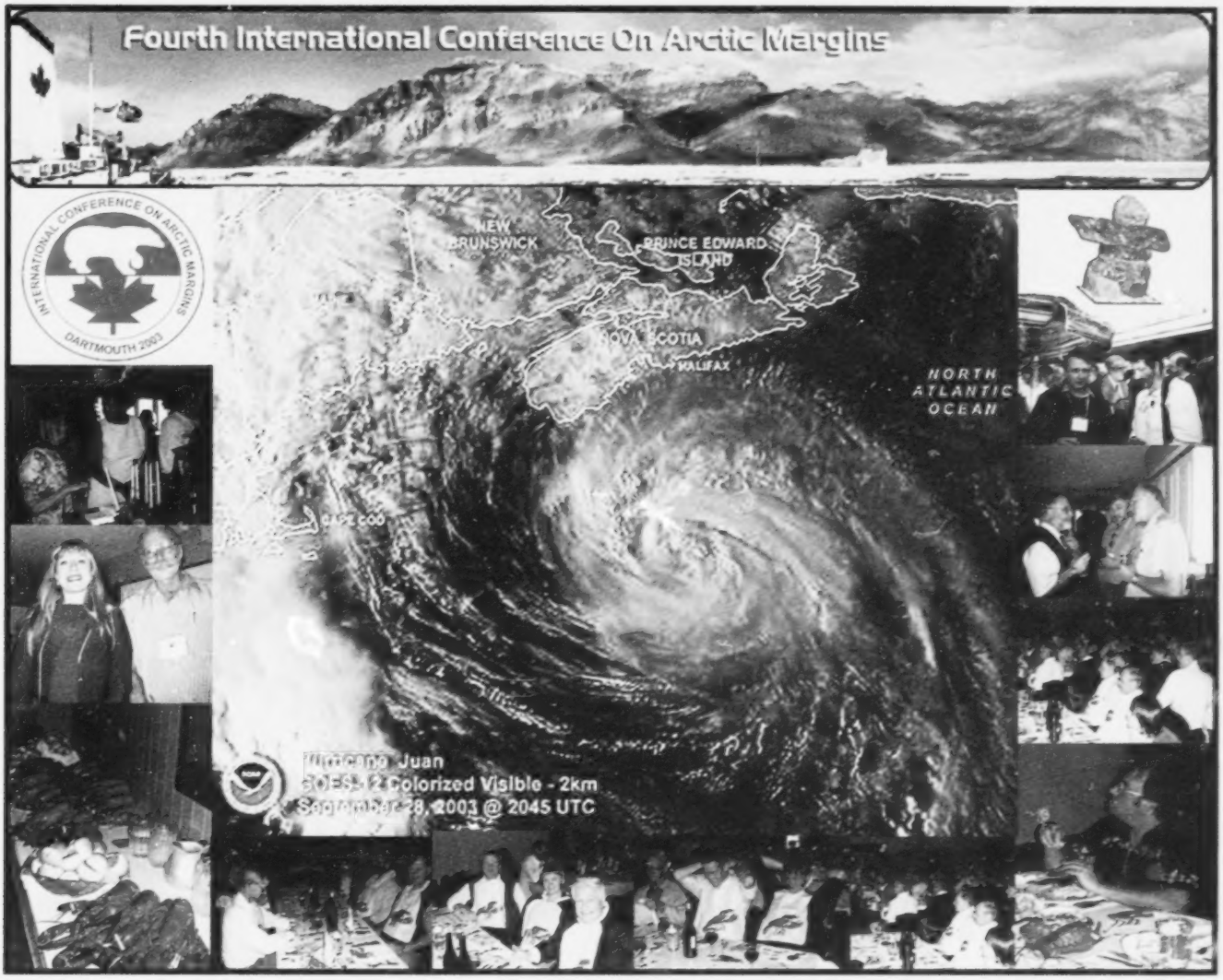
The **Workshop to draft the Regional Action Plan implementing the new (2002) Aquaculture Policy Framework (APF)** was held at BIO, January 28-29, with key personnel from most sectors of DFO Maritimes and the Office of Sustainable Aquaculture in Ottawa attending. The Workshop was organized, chaired, and facilitated by the Aquaculture Coordination Office. Participants outlined elements of the Action Plan and built on cross-sectoral work done at Aquaculture focus sessions the previous fall. The Action Plan that was developed has been "mapped" to show its linkages to the APF and other policy documents. Performance measures and linkages to fiscal resource levels are being added to make a comprehensive management package. This, the third in a series of three focus sessions, resulted in the creation of the Maritimes Region Action Plan to implement the APF.

The second **Eastern Scotian Shelf Integrated Management (ESSIM) Forum** was held February 18-19 at Mount St. Vincent University in Halifax. The Forum was organized by the Oceans and Coastal Management Division and NRCan with the assistance of a multi-sectoral planning team. The purpose was to promote cross-sectoral dialogue and capacity building for integrated ocean management and planning, and to discuss key elements of the paper, *A Strategic Planning Framework for the Eastern Scotian Shelf Ocean Management Plan*. The intent of the *Strategic Planning Framework* is to guide the development of the future Ocean Management Plan, identify and link the basic plan elements required for integrated management, and provide a long-term basis for addressing the full range of ocean management requirements in the Eastern Scotian Shelf Large Ocean Management Area. While important guidance and priorities for next steps were received, the ESSIM process itself is valuable as a vehicle for government coordination and commitment, as a forum to raise awareness, for communications and issue identification, and as a catalyst for ecosystem approaches to ocean management.

The workshop **Objectives Based Fisheries Management (OBFM)** was held in Halifax, April 15-16. Thirty-one participants represented stakeholders of the inshore scallop resource including fishermen, federal and provincial governments, Aboriginal communities, and NGOs. OBFM is a DFO joint Science and Fisheries Management initiative. The Bay of Fundy scallop fishery is one of two pilot projects in Scotia-Fundy designed to implement the OBFM concept. OBFM is the first nationally coordinated attempt to implement the precautionary approach to Canadian fisheries. It incorporates concepts defined internationally and nationally within the Rio Declaration, the FAO Code of Conduct for Responsible Fisheries, Canada's *Oceans Act*, and elsewhere. OBFM involves setting measurable objectives, developing strategies designed to meet them, and defining unacceptable outcomes which are mitigated by pre-agreed corrective actions, all within an atmosphere of co-management and transparency of process. The workshop's main purpose was to disseminate information on OBFM and begin the definition of objectives for this fishery—the first step toward the production of an OBFM-based management plan.

In May, the BIO Library organized a **workshop for the local library/archives community.** A professional conservator gave a hands-on workshop on how to make phase-boxes, a type of protective enclosure useful for preserving frail, damaged, or rare books.

The Offshore Oil and Gas Environmental Effects Monitoring (EEM) Workshop: Approaches and Technologies was hosted by COOGER at BIO May 26-29. The workshop provided a forum for sharing international knowledge and experiences and to address whether environmental effects monitoring programs are providing



Highlights from the ICAM Conference include a candlelit wine and cheese reception and lobster banquet, both shown above. Participants, from left to right, include, from NRCan, conference chair, Dr. Ruth Jackson, and conference worker Carmelita Fisher; reception host Ron Macnab (DFO); many ICAM participants; and speakers, from NRCan, Gordon Ockey, Steve Blasco, and Steve Solomon.

the necessary information, and how they might be improved. (*See article: Offshore Oil and Gas Environmental Effects Monitoring Workshop.*)

The **Atlantic Science Forum Steering Committee** sponsored the symposium, **Protecting Habitat in Atlantic Canada,** in Moncton, May 22-23. Wendy Watson-Wright, DFO Assistant Deputy Minister, gave the keynote speech, *Federal Government Departments: Working Together in Changing Times*. The objective of the forum was to identify the gaps in habitat protection activities and generate a collaborative action plan to address them. Participants from the twelve federal departments in attendance shared information about their activities in the area of habitat protection. The Steering Committee, chaired by NRCan, is comprised of senior Science and Technology representatives nominated by each of the four Atlantic Federal Councils, and was formed to organize collaborative events for Atlantic federal scientists and science managers.

In June, the joint meeting of the **Canadian Quaternary Association (CANQUA) and the Canadian Geomorphological Research Group (CGRG)** was held at BIO and Dalhousie University, Halifax. The **2003 CANQUA-CGRG** meeting attracted 130 scientists from Canada, the United States, Europe, and Asia.

In August 2003, the OCMD hosted a meeting in St. Andrews, New Brunswick for the **Gulf of Maine Summit Planning Committee**. Comprised of citizens, NGOs, and provincial, state, and federal government employees from around the Gulf, the committee met to plan the Gulf of Maine Summit, to be held in St. Andrews, in October 2004. The Summit will assess the health of the Gulf of Maine ecosystem and resources from the bottom up, taking full advantage of and integrating all initiatives underway by many agencies and organizations in the Gulf area.

The **Fourth International Conference on Arctic Margins (ICAM)** was to be hosted by NRCan at BIO, September 30-October 3. Hurricane Juan struck the area 36 hours before the conference was to begin, effectively cancelling all arrangements. Besides the many local scientific staff who were to attend, more than 80 delegates had

Highlights from the ICAM Conference include a sandbox wine and cheese reception and closing banquet, both shown above. Participants, from left to right, include Tom McCann, conference chair; Dr. Ruth Jackson, and conference worker Cornelius Fisher; reception host Ron Macnab, DFO; more ICAM participants; and speakers Tom McCann, Gordon Oakey, Steve Blasco and Steve Solomon.

the necessary information, and how that might be improved (see article, Offshore Oil and Gas Environmental Effects Monitoring Workshop).

The **Atlantic Science Forum Steering Committee** sponsored the symposium, **Protecting Habitat in Atlantic Canada**, on March 22-23. Wendy Watson-Wright, DFO Assistant Deputy Minister, gave the keynote speech. Federal-provincial partnership, Working Together for Lasting Fish, The challenge of the Fisheries to achieve the goals of habitat protection, recovery and restoration, collaborative action plan to address Atlantic Canada's priorities, and the role federal departments in providing advice and information to their activities in the area of habitat protection. The Steering Committee, chaired by Mike Sinclair, comprised Science and Technology representatives associated with each of the Atlantic Federal Councils, and was formed to support the Council Committee for Atlantic Habitat activities and science strategies.

In June, the joint meeting of the **Canadian Quaternary Association (CANQUA)** and the **Canadian Geomorphological Research Group (CGRG)** was held in Dalhousie and Halifax, Nova Scotia. The 2003 CANQUA-CGRG meeting attracted 150 scientists from Canada, the United States, Europe and Asia.

In August 2003 the ICAM Board of Directors met in St. Andrews, New Brunswick with the **Gulf of Maine Summit Planning Committee**. Comprised of Canada, NGOs and provincial, state and federal governments, they met to consider how the conference could help give the Gulf of Maine Summit a push. The Summit was held in St. Andrews in October 2004. The Summit will assess the health of the Gulf of Maine ecosystem and identify the priorities for future work to advance the ecosystem approach to management in the Gulf of Maine.

The **Fourth International Conference on Arctic Margins (ICAM)** was held in Dartmouth, Nova Scotia, from September 29 to October 3. Hosted by the Bedford Institute of Oceanography, the conference brought together scientists from around the world to present the results of research on the Arctic Ocean and its continental margins. Over 200 participants from 12 countries attended the conference, which was chaired by Tom McCann, Geological Survey of Canada (Atlantic). Dr. Ruth Jackson, Geological Survey of Canada (Atlantic), was the conference co-chair.

First Nations Elders at Bras d'Or Integrated Management Workshop

travelled to Halifax for the conference. In a two-hour period on September 29, the organizing committee, with the help of volunteers, re-organized two years' worth of arrangements. Many participants expressed awe at this "quick on your feet" response, and after the conference, one sent the message: "If you were ever looking for creativity and versatility in our organization, you are sure to find it in Halifax. Hats off to the organizers."

A successful **Bras d'Or Integrated Management Workshop** was held October 8-10, in the Cape Breton communities of Eskasoni and Wagmatcook. Hosted by the Unama'ki Institute of Natural Resources and sponsored by DFO, Environment Canada, and Indian and Northern Affairs Canada, the workshop provided First Nations and federal, provincial, and municipal levels of government an opportunity to develop a common understanding and method of advancing an Integrated Management process for the Bras d'Or Lakes and watershed lands. Emphasis was on how governments and First Nations can collaborate to address the many sustainability issues in this area. This approach is consistent with Canada's *Oceans Act* and its associated Integrated Management Policy.

A second public workshop, to include NGOs, industry, businesses, and interested community members, is planned to establish a process and structure for how stakeholders can work together to address key issues around the Lakes including sewage contamination, closed fisheries, impacts from land development and forestry, youth out-migration, invasive species, high unemployment, and others.

COOGER hosted an **Oil Dispersant Research Planning Workshop** at BIO on November 26. Participants identified the scientific information required to improve decision-making, operations, planning, and environmental analysis and emerging issues related to chemical oil dispersant use. Participants came from the DFO regions of Maritimes, Gulf, Newfoundland, and Quebec; Queens University; and France's Centre de documentation de recherche et d'expérimentations sur les pollutions accidentelles des eaux.

On November 27, the Centre for Marine Biodiversity (CMB) held a **workshop on data management challenges in support of biodiversity inventories, monitoring, and research**. BIO is seeking to establish a shared vision regarding open standards-based exchange of biological data. CMB expects to strongly influence the publishing of marine biodiversity data via international standards and to effectively lead development of a Canadian Ocean Biography Information System (OBIS) portal. BIO, as part of the Canadian Geospatial Data Infrastructure, is presently installing data provider and web mapping services, such that marine biological and fisheries data from DFO as well as CMB member sources can be published via the OBIS International and Global Biodiversity Information Facility systems. This workshop brought together several groups involved in this initiative.

Bras d'Or Lakes area

Ten departments were represented at a workshop for the **Science Opportunities System (SOS)** held on December 1, at BIO. A branch of the Career Opportunities System, SOS is aimed at providing learning and career opportunities for S&T leaders and workers. An initiative of the National S&T Secretariat in Ottawa, the workshop's purpose was to design the SOS pilot project which will come into effect in the Halifax area in 2004, with the goal of implementing the system at the national level.

SPEAKERS AND SPECIAL EVENTS

The **BIO Seminar Series** hosted two speakers in 2003. On September 9, Dr. Bob Park of the American Physical Society presented *The Seven Signs of Voodoo Science*. Dr. Park introduced seven common warning signs that should alert the public, as well as other scientists, about questionable science claims. On October 20, Dr. Anne Trehu of Oregon State University gave the lecture *Distribution and Concentration of Gas Hydrates in Nature*. Gas hydrate is an ice-like compound of water and methane that forms at conditions found beneath the seafloor on continental margins. Because methane is a powerful greenhouse gas, sudden destabilization of the methane trapped in gas hydrates may be a factor in global climate change. This methane may also be an energy resource for the future.

The Centre for Marine Biodiversity (CMB) presented the talk, ***Big Predators in the Jungles of the Mind***, by award-winning, Montana-based writer David Quammen on October 14. In his lecture, based on his book *Monster of God: The Man-Eating Predator in the Jungles of History and the Mind*, he addressed the question of whether, given current trends of human population growth and landscape conversion, any populations of big predators will continue to exist in the wild beyond the year 2150. If not, what will have been lost—in mythical and psychological terms, as well as ecological ones? David Quammen has written several works of fiction and volumes of essays including, *To Walk the Line*, *Natural Acts*, *The Song of the Dodo*, and *Wild Thoughts from Wild Places*.

On October 23, the CMB, in conjunction with the World Wildlife Fund, Marine Invertebrate Diversity Initiative, and DFO, hosted at BIO **a public celebration of marine biodiversity**. The event featured a poster session and slide show on local marine life by Maria-Ines Buzeta and Mike Strong of DFO St. Andrews, followed by the lecture *Tales of Mystery and Imagination: Life at Deep Sea Hydrothermal Vents* by Anna Metaxas, a professor of oceanography at Dalhousie University.

On June 26, BIO employees toured the new **Energy Centre Cooling Plant**, one of the key milestones in revitalizing BIO. On hand to answer questions were Project Manager Greg Gromack; a representative from the architectural firm which designed the facility, WHW; and Public Works and Government Services Canada staff who operate the cooling plant, which is notable for its sustainable development ("green") features.

A **Diversity Event** was held at the Institute on November 13, 2003. The program featured the inspirational speaker and singer, Terry Kelly, who also led a workshop on diversity in workplace issues. The young Mi'kmaq groups, Eastern Eagle Singers and Four Directions Dancers, performed an Aboriginal Drumming and Dancing ceremony.

VISITORS

On May 2, the sailing vessel ***Sedna*** arrived at BIO. From its home port of Cap-aux-Meules, Quebec, the 51-meter, three-masted, steel-hulled sailing vessel was on a mission to produce a five-episode National Film Board television series on the Arctic and Climate Change for *The Nature of Things*. *Sedna*'s voyage is a circumnavigation of North America via the Northwest Passage and Panama Canal. This provides a rare opportunity for scientists to address ecological phenomena emerging at large, biogeographic spatial scales. An ancillary science program—*A Macroecology Survey of North American Coastal Waters*—is being conducted by a science team that includes researchers from the University of Victoria as well as from DFO in the Maritimes, Pacific, and Central & Arctic regions.

Larry Murray, DFO Deputy Minister, visited on June 23 for talks on the BIO renovations, the SeaMap proposal, and technological innovations in the development of oceanographic instrumentation and commercialization.

Jorgen Holinquist, Science Director-General within the European Union government system, visited BIO on July 3. The focus of discussion was on the provision of scientific advice on fisheries.

On September 8, the **Honourable Robert Thibault** gave a presentation to the media on a new Memorandum of Understanding with the Center for Coastal Studies, a United States organization that has unique expertise in untangling whales from fishing gear. They will provide training and assistance to Canada in support of the Right Whale Recovery Plan.

Mr. Fan Fengxin, **Mr. Chen Changan**, and **Mr. Wang Weiyuan**, from the Chinese Academy of Science, met in October with NRCan

Bras d'Or lakes area

a public celebration of marine biodiversity

Energy Centre

Cooling Plant

Diversity Event

Sedna

Larry Murray

Jørgen Holmquist

Honourable Robert Thibault

Mr. Fan Fengxin Mr. Chen Changan Mr. Wang Wenxuan

scientists to exchange information and discuss sediment transport and seabed stability research.

Seven **government leaders from Nigeria** visited in December to learn about the science knowledge necessary for supporting their UNCLOS claim (beyond 200 nautical miles). They toured BIO, with a focus on CHS and NRCan programs.

AWARDS, HONOURS, AND TRIBUTES

Throughout 2003, employees at BIO were honoured for their achievements and contributions to their disciplines or Departments.

At the 38th Congress of the Canadian Meteorological and Oceanographic Society (CMOS) in May-June, **Allyn Clarke** was elected president of the Society. CMOS is the premier organization of professional atmospheric and oceanographic scientists in Canada, sponsoring an annual scientific congress, two regular publications, and several national coordination committees, and featuring fourteen Society centres and chapters across the country that serve as focal points for local and regional activities.

In recognition of his multi-disciplinary creativity and contributions to the scientific community, **Kenneth Lee** was appointed to the editorial board of the journal, *Spill Science & Technology Bulletin*. This international, peer-reviewed journal on oil and chemical spill science and technology focuses on the effects and control of discharges of oil, oil products, and other hazardous substances. Its aim is to serve as a global forum for the exchange of high quality technical and scientific information among professionals engaged in spill prevention, response, and assessment.

On December 14, the Gulf of Maine Council Visionary Award for Nova Scotia was presented to **Kenneth Mann** for his outstanding contribution to the understanding of the coastal ecosytems of the northwest Atlantic Ocean. Visionary Awards are presented to those who have displayed commitment and dedication to the preservation of the marine environment of the Gulf of Maine.

Graham Williams, NRCan Research Scientist, was the winner of the Atlantic Provinces Council on the Sciences (APICS)/Canpolar Sciences Communications Award. This annual award to an Atlantic scientist, chosen by APICS and funded by CanpolarEast Inc., was presented to Graham in recognition of his record in science awareness efforts. He was a leading force in the publication of *The Last Billion Years: a Geological History of the Maritime Provinces*.

The **Canadian Hydrographic Service (Atlantic)** (CHS) was awarded the Employer of the Year award by Connections Clubhouse on October 29. **June Senay** of CHS was named Supervisor of the Year for her excellent qualities of supervision. Connections Clubhouse and Laing House are not-for-profit organizations that CHS has contracted to assist in the capture of digital source data. They assist individuals who have experienced mental illness to build capacity and return to work. Dating back to the "Cabot 500" contract in 1997, their staff have worked very hard supporting a number of CHS surveys and projects, creating digital source for CHS products. This first opportunity has been the stepping-stone to regular employment for many, and has been a win-win situation for all.

The twenty-sixth **A. G. Huntsman Award** was presented to **Dr. Lynne D. Talley** at a special ceremony at BIO on November 5. Dr. Talley, the first female winner of this award, was honoured for her outstanding contributions to the understanding of the circulation and ventilation of the global ocean. Dr. Talley is a Professor at the Scripps Institution of Oceanography in La Jolla, California. Throughout her career she has illuminated the overturning circulation of the oceans through her assembly and synthesis of large datasets. As well, she has published significant analytical studies of oceanic processes such as barotropic instabilities, ventilated thermocline theory, and mixing and convection. She has led oceanographic expeditions in all of the major ocean basins except the Arctic and has chaired national and international scientific steering committees for major ocean climate programs such as the World Ocean Circulation Experiment.

Lynne Talley receives the Huntsman Award from Dr. Garry Rempel of the Royal Society of Canada. Following the presentation, Dr. Talley delivered her distinguished lecture, Global Freshwater Balances and Transport. A champagne reception concluded the ceremony.

Dr. Talley holds a Bachelor of Arts in Physics and a Bachelor of Piano Performance from Oberlin College, and a Ph.D. in Physical Oceanography from Woods Hole Oceanographic Institution and Massachusetts Institute of Technology. She has received the 2001 Rosenstiel Award and a 1987 U.S. National Science Foundation Presidential Young Investigator Award, and is a Fellow of the American Academy of Arts and Sciences.

Arthur Cosgrove, head of DFO's Drafting and Illustrations Group, was awarded the **BIO-Oceans Association Beluga Award** in recognition of his leadership and outstanding contribution to excellence in scientific illustrations over more than 30 years at BIO.

The **BIO Science Display Award** for 2002/2003 went to BIO participants: John Shaw, Bob Taylor, Gary Grant, Rhonda Sutherland, Brenda Topliss, Ken Drinkwater, R. Cox, and G. Parkes; from Environment Canada: S. Szabo, W. Groszko, T. Clair, G. Lines,

Science Display Award, from left: Michael Sinclair, Director BIO; John Shaw; Jacob Verhoef, Director, NRCan; and Gary Grant

and R Elliot; S. Murray from Agriculture and Agri-food Canada; and Norman Catto from Memorial University, for *The Tides of Change* (Climate Change in Atlantic Canada). Second prize was awarded to Peter Amiro and Art Cosgrove for their exhibit, *Inner Bay of Fundy Salmon*. The BIO Science Display, located on the 4th floor of the Holland building, provides an opportunity for BIO scientists to showcase their work to both visitors and colleagues in other disciplines. The display content is changed monthly and at year-end the submissions are judged on visual impact, communication value, and science promotion value, among other factors.

Several at BIO were awarded the **DFO Deputy Minister's Prix d'Excellence**. **Gerard Costello** and **Bruce MacGowan** of CHS each received a Prix d'Excellence with other members of the MultiRegion Science Sector, Data Processing Working Group (DPWG). Drawn from a variety of disciplines and all CHS regions, through their inter-regional cooperation, consultation, and collaboration with partners in the academic and private sectors, the DPWG has advanced oceanography and contributed much to the safety of navigation in Canada. The team's challenge involved the processing of high volume data sets collected by Multibeam Echosounder Systems. Their new generation of processing software cuts processing time to a fraction of what it once was and can now be run on an inexpensive PC platform.

The following were recipients of both the Prix d'Excellence and **Regional Merit Awards**. **David Duggan, Darrell Harris**, and **René Lavoie** were members of the **MSX Team from Gulf and Maritimes Regions Science, Fisheries Management, and Oceans Sectors**. Following the detection of the MSX disease in oysters taken from St. Patrick's Channel, Bras d'Or Lake, Cape Breton, DFO and provincial fisheries Departments moved quickly to determine the scope of the problem. While posing no risk to humans, MSX is a serious threat to the east coast oyster fishery. The team was remarkably successful in managing the MSX crisis by quickly identifying the potential risks, gaining the confidence of stakeholders, and forming the horizontal networks and partnerships essential in managing a complex multi-jurisdictional issue. The team's management of the crisis can be considered a model for managing ongoing files and other emerging issues.

Robert O'Boyle was a member of the team whose efforts were instrumental in the successful implementation of the Canada/USA Cooperative Fisheries Management Framework, an innovative sharing agreement for the transboundary groundfish resources on Georges Bank. This was accomplished through their early work in the formation of the Transboundary Resource Assessment Committee in 1998 and the Transboundary Management Guidance Committee in 2000. The Framework will realize conservation and economic benefits to both countries.

Robert Rutherford was honoured for his longstanding commitment to and national leadership in oceans and coastal management and conservation. He helped draft the regulations for the design and establishment of The Gully Marine Protected Area, developed internal mechanisms that turned the 1997 *Oceans Act* into reality, and led the development of the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative.

With a career devoted to the understanding and management of resources of the world's oceans, **Michael Sinclair** is one of DFO's leading researchers. His work has influenced the course of research at the regional, national, and international levels and has made a profound impact on the global direction of marine research. Among his many projects has been the establishment of the Centre for Marine Biodiversity at BIO. As a promoter of educational opportunities for Aboriginal students he was active in the creation of the Unama'ki Fisheries and Oceans Canada Scholarship. Through BIO's Hypatia Project, he is also a champion of women in science and technology.

Two BIO staff received a **DFO Assistant Deputy Minister's Commendation Award**. **Rosalie Allen Jarvis,** COOGER Program Coordinator, was honoured as part of the team that organized the

DFO Merit Awards Ceremony, including the honourees from BIO

Aquatic Science 2020 workshop that took place in Montreal in May 2003. In June, **John Smith** of the Marine Environmental Sciences Division received the Award in recognition of exceptional contributions to chemical oceanography research as part of an inter-regional team of scientists.

The **DFO Merit Award** is based on "the successful completion in a matter beyond what could normally be expected by management, of a major project, special assignment, or research study." At the Merit Award ceremony in June, the following BIO staff were honoured.

René E. Lavoie, Gary Bugden, and **Dave Duggan** were instrumental in developing a Memorandum of Understanding (MOU) between the Unama'ki Institute of Natural Resources (UINR) and BIO. The major goal of the MOU is to enhance research in the Bras d'Or Lakes and watershed by First Nations and DFO and will assist UINR in developing capacity for science and resources management.

Doug Regular, Nick Stuifbergen, and **Craig Zeller** of the CHS contributed to the On Datum Project to transform 154 Nautical Charts for CHS Atlantic Region from North American Datum 1927 (NAD27) to North American Datum 1983 (NAD83). This represented 56% of CHS Atlantic Region's 286 Nautical Chart portfolio. The project also included the recovery of 54 charts that were published originally on an unknown datum and are now referenced to NAD83 directly with the chart, making it convenient for the mariner to plot his position on the NAD83-referenced chart. To achieve this goal successfully required innovation, co-ordination, flexibility, and teamwork and is an example of the "can do" approach necessary to achieve difficult objectives on time with a minimum of resources.

Bruce Anderson, who has worked for DFO Maritimes in a number of capacities since 1984, was recognized for his contributions to DFO. In 1996, he joined CHS where his work in Hydrography and Chart Production and Maintenance has been exemplary. Bruce is a devoted, hard working, highly motivated individual who is always willing to take on challenging responsibilities and as a team member, gives freely of his time and knowledge to assist others.

Brenda Topliss made an outstanding contribution to the promotion of women and applications of remote sensing in science, through serving as the Editor of the Special Issue of the *Canadian Journal of Remote Sensing*. The issue, "Women Sensing the World", is a compilation of papers from around the world authored by women scientists. Brenda initiated the Special Issue to highlight the breadth and depth of the excellent research being done by women in the field of remote sensing and to foster collaborations and networking for women in this field.

Bechara Toulany's dedication and careful development and execution of complex computer projects over the past decade have been critical factors to the development of a leading edge research capability on numerical modelling of ocean waves and other atmosphere-ocean coupling in the North Atlantic. He was honoured also for his lead role and high-quality performance in the complex implementation of a state-of-the-art, high resolution ocean wave model for Atlantic Canada. This has provided the basis for the Ocean Science Division's participation in various national and international research programs on air-sea interactions relevant to climate and operational oceanography.

NRCan Merit Awards honour staff for their support of NRCan's vision, mission, goals, and objectives; enhancement of the organization's profile; and contributions to its success.

Ruth Jackson received an NRCan **Sector Merit Award** in recognition of her ability to organize and lead a multi-disciplinary international scientific cruise to the Nares Strait. This cruise brought together scientists from Denmark, Germany, the Geological Survey of Canada (NRCan) and Dalhousie University.

Division Merit Awards went to:

Austin Boyce for dedicated support to the acquisition of the highest quality sidescan sonar data in cooperative projects between NRCan and DFO;

Claudia Currie for key contributions to the organization of the BIO 40th Anniversary slide show and other Division-wide events;

Nelly Koziel for tireless efforts in organizing special events for Division staff;

Bill MacKinnon for excellent efforts in coordinating office and staff moves.

Division awards were presented also in recognition of their spectacular efforts in organizing and/or re-organizing the International Conference on Arctic Margins to:

Bruce Anderson, CHS
Steve Blasco, NRCan
Lori Cook, NRCan
Claudia Currie, NRCan
Rob Fensome, NRCan
Carmelita Fisher, NRCan
Dave Frobel, NRCan
Tim Hannon, NRCan
Bob Harmes, NRCan
Ruth Jackson, NRCan
Joe Koziel (spouse)
Nelly Koziel, NRCan
Bill MacMillan, NRCan
Mary Macnab (spouse)
Ron Macnab, CHS (formerly of NRCan)
Phil Moir, NRCan
Gordon Oakey, NRCan
Patrick Potter, NRCan
Bill Schipilow (spouse)
Cathy Schipilow, CHS
John Shimeld, NRCan
Phil Spencer, NRCan
Graham Williams, NRCan

At the BIO barbeque in June celebrating National Public Service Week, Michael Sinclair made a special presentation to **Mike Friis** of the BIO Mail Room. In appreciation for his 25 years of dedicated service to staff at the Institute, Mike was made a Life-Time Honourary Member of BIO. He was further honoured at his retirement party in December, when he was made an Honorary Member of the BIO-Oceans Association.

Mike Friis

The inaugural year recipients of the **Unama'ki Fisheries and Oceans Canada Scholarship** were **Martin Willison** (professor) and **Shauna Barrington** (student) for their project *Creating a Strategic Action Plan for the River Denys Watershed, Nova Scotia*. The Scholarship is awarded jointly by DFO and Unama'ki Institute of Natural Resources (UINR) to a Dalhousie University team consisting of a graduate student and a faculty member judged to have submitted the best proposal for a graduate research project on a topic related to the natural resources of Cape Breton Island in general and the Bras d'Or Lakes ecosystem in particular. The award consists of a graduate scholarship tenable at Dalhousie University valued at $20,000 per year and an accompanying research and travel grant of $10,000. The winning team will carry out its research project on Cape Breton Island and at Dalhousie University in cooperation with the UINR and DFO. The successful project is expected to contribute to the existing research directions of the Research Institute and the Department. The researchers undertake to mentor a high school student from one of the Cape Breton First Nations, and include this student in their research activities for not less than two months during the summer of each year in which the project is active.

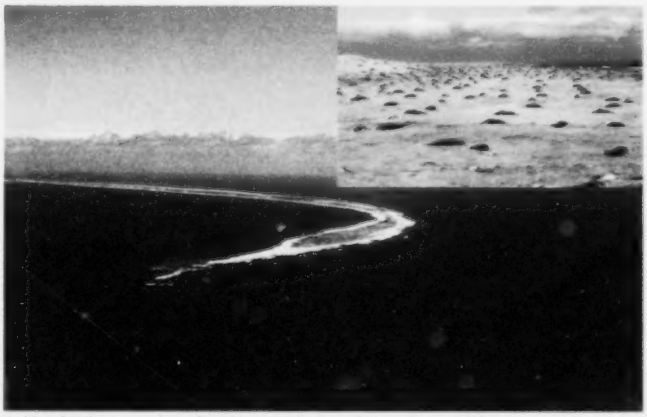
Science Activities

Atlantic Seal Research Program: Grey Seal Predation in Continental Shelf Ecosystems

- Don Bowen and Jim McMillan

For more than a decade, the effects of the closure of fisheries on groundfish stocks throughout eastern Canada has focused attention on the factors contributing to the collapse of those stocks, and more recently on the factors promoting their recovery. However, this regional focus is also part of a much broader global interest in understanding the relative effects of fishing, environmental change, and predation on the dynamics of commercially important fish populations. The abundance and productivity of fish species is influenced by changes in ocean climate, which in turn can affect the food available at lower trophic levels. These are called bottom-up effects. However, top-down effects of predators and humans may also influence prey populations. Such effects are relatively well understood in some terrestrial ecosystems, but are not well understood in marine ecosystems. Top predators, such as seals, whales, and sharks, are thought to exert top-down effects on prey populations as evidenced by the view that seals may have been a factor in the collapse of cod stocks and are preventing their recovery.

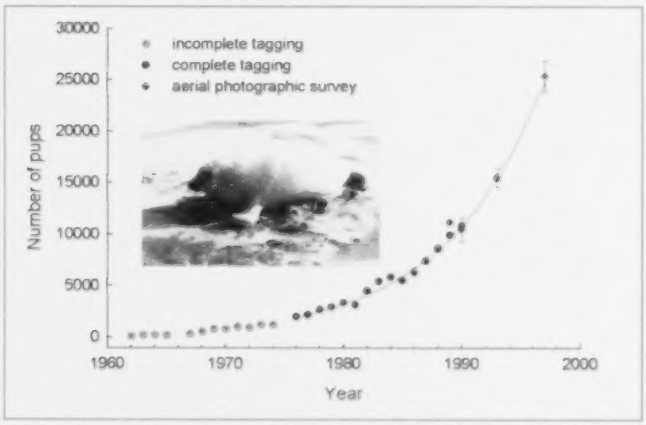
On April 24, 2003, the Government of Canada announced the re-closure of three cod stocks in the Gulf of St. Lawrence and northeast of Newfoundland and Labrador. Recent scientific assessments of these stocks determined that they were at historically low levels despite a decade of severe conservation measures. Similarly, the eastern Scotian Shelf stock of Atlantic cod is currently at historically low levels despite a moratorium on fishing since 1993. Among other factors, predation by seals is hypothesized as a factor contributing to the high mortality of cod. Thus, as part of this announcement, the Minister of Fisheries and Oceans announced a two-year science program to expand current research to advance our understanding of the complex interaction between seals and fish stocks. The Atlantic Seal Research Program (ASRP) has two main goals: 1) to provide current information on the extent of seal predation on cod, and 2) to provide scientific advice on management actions that could reduce current and future levels of seal predation on cod. To achieve these goals, ASRP will estimate current population sizes of harp, hooded, and grey seals, determine the areas where seals and cod co-occur, and estimate the amount of cod consumed by seals. In the context of this program, research at BIO will focus on the abundance, distribution, and diet of grey seals to estimate their top-down effects on Atlantic cod and other fish species.



Sable Island approaching from the west by air and small part of the grey seal breeding colony in January

ABUNDANCE OF GREY SEALS

Estimates of the number of pups born each year (also called pup production), coupled with reproductive and survival rates, are used to project total population size and to predict population trends of grey seals. Grey seals give birth at several sites along coastal Nova Scotia, in the southern Gulf of St. Lawrence, and more recently in



Number of grey seal pups born on Sable Island over the past four decades

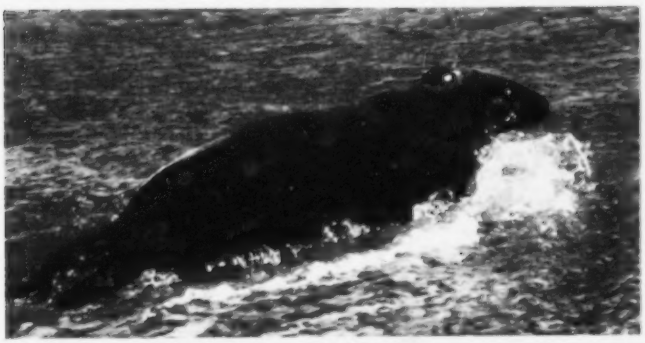
Sable Island horses

Maine and Massachusetts. However, the breeding colony on Sable Island is by far the largest in the Northwest Atlantic and in fact represents the largest grey seal breeding colony in the world. The increase in pup production on Sable Island has been dramatic over the past four decades. With an annual rate of increase at nearly 13%, grey seal pup production on Sable Island has doubled about every seven years. However, there is no guarantee that this rate of increase has continued. Thus, an objective for 2004 is to conduct a complete aerial photographic survey of Sable Island to determine current pup production and to estimate total population size. Incidentally, this survey will also permit a count of the number of horses on the island.

GREY SEAL HABITAT USE

Grey seals are wide-ranging and mobile predators in eastern Canadian waters, capable of feeding on different fish stocks over short periods of time. Therefore, it is important to determine where seals feed in order to estimate the amount of seal predation on each cod stock. Previous estimates of cod consumption by grey seals have been based largely on indirect evidence about seal distribution. For example, seal distribution has been inferred from flipper-tag returns, which presumably reflects hunting and fishing effort as much as it does seal distribution. Thus, relatively little is known about the habitats used by seals and, with several exceptions, areas of co-occurrence of cod and seals also are poorly known. This lack of knowledge is understandable since it has only recently been possible to obtain information on the movements of free-ranging seals.

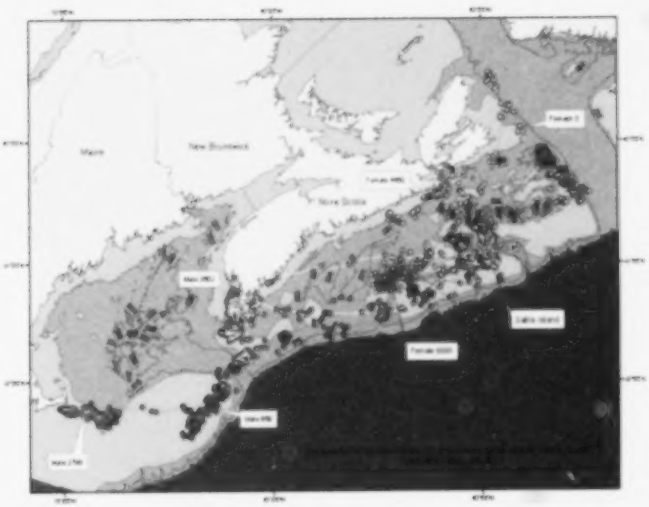
The development of satellite tags has revolutionized our ability to study the foraging location of seals, and other predators, and the relative importance of different habitats. These satellite tags transmit information to the Argo satellite system, which permits the location of a seal to be determined. We have used satellite tags to track the movements of adults, but more studies are needed to provide reliable information on seasonal habitat use. Our research on adults will continue, but the focus of our new studies, under ASRP, will be to determine the distribution of juvenile grey seals, as they account for almost half of the fish consumed by grey seals.



Adult female grey seal fitted with an Argo satellite tag

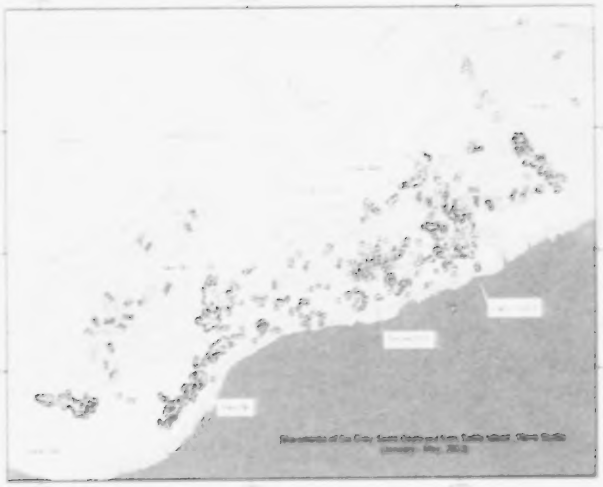
GREY SEAL PREDATION ON COD

Seal diets are known to vary significantly in both time and space. This is not unexpected given that the abundance of prey species also changes over time and space. Therefore, estimates of what seals have eaten in the past may not be relevant today. We know from previous studies that grey seals do eat cod. However, those studies revealed also that cod was a relatively minor part of the diet compared to capelin,



Movements of adult grey seals from June to December based on locations from satellite tags

Sable Island horses



sand lance, and flounders. We also know that previous studies, based on the recovery of prey hard parts, may have missed some prey and misrepresented the importance of others. In ASRP, we are using quantitative fatty acid signature analysis (QFASA), a new method developed by a group including scientists from BIO, and led by Sara Iverson, Dalhousie University. This method of determining what seals eat does not depend on the recovery of prey hard parts, such as otoliths (fish ear bones) but integrates the diet over weeks to months, providing a better understanding of the foods eaten by seals. QFASA estimates of diet from blubber biopsies taken from adult grey seals during the late 1990s indicated that sand lance, redfish, capelin, and herring were among the most frequently eaten fishes. Cod, pollock, and other groundfish were also eaten but were minor components of the diet. Our aim in ASRP is to update the QFASA estimates of diet for adult grey seals and to extend estimates to include juveniles so that all components of the population will be represented.

This integrated approach to research will provide a better understanding of the ecological role of grey seals in marine ecosystems and will contribute to the management of marine fishes in eastern Canadian waters.

Live Gene Banking of Endangered Populations of inner Bay of Fundy Atlantic Salmon

- Patrick O'Reilly

The window of opportunity for conserving wild anadromous Atlantic salmon in southern portions of the species range, where runs have been either extirpated or reduced to very small numbers, is rapidly closing. Elevated levels of marine mortality are accelerating the decline of many remaining salmon runs, compounding the previous impacts of acid precipitation, river obstructions, and other human disturbances. The geographic isolation of remaining viable populations makes the recolonisation of extirpated rivers via natural strays, when conditions improve, unlikely in any reasonable timeframe. Furthermore, it is uncertain whether the use of salmon from distant locations, via transplantation of naturally produced juveniles, or stocking of hatchery reared salmon, will be effective in restoring populations. Tagging studies involving hatchery produced coho and Atlantic salmon smolt have found that marine survival of stocked fish decreases with increasing coastal distance between recipient and source rivers, suggesting possible heritable differences in marine migration routes among populations. Also, salmon from more stable northern populations may be maladapted to river conditions in the south. For example, when reared in common environments, Atlantic salmon obtained from higher latitude rivers exhibit higher growth rates and conversion efficiencies than salmon collected from southern rivers; this so called countergradient pattern has also been observed in a number of other fish species. Given these observations, and accumulating evidence for the existence of other adaptations in salmonids on small and medium spatial scales, it would seem prudent to conserve a few remnant southern populations before the last is forever lost.

The inner Bay of Fundy (iBoF) recovery team, which included representatives of national and provincial governments, universities, Aboriginal communities, non-government organisations, and local industries, identified the use of Live Gene Banks (LGBs) to achieve the short-term objective of "harbouring and protecting" residual populations, for the eventual long-term goal of restoring self-sustaining populations to the inner Bay. The first step in this process was to identify which of the remaining iBoF rivers should receive the majority of conservation efforts. The two primary LGB rivers chosen, the Stewiacke and the Big Salmon, drain into the two geographically distinct regions of the inner Bay, the Minas Basin and the Chignecto Bay. Published research indicated that many salmon of the Minas Basin belonged to a distinct lineage of mitochondrial DNA not observed elsewhere in the species distribution. The Stewiacke and Big Salmon Rivers, therefore, were also thought to represent two genetically distinct assemblages of iBoF salmon. These two runs were also among the last to decline, and likely harboured the largest number of returning adults at (or just prior to) the time of collection of the LGB founder populations. The increased census size, and likely increased effective population size, is reflected in the higher levels of genetic variation compared to other rivers of the inner Bay.

LGB programs, by necessity, involve multiple generations of captive rearing to shelter populations at imminent risk of local extirpation. When used to re-establish natural populations, LGB-restoration programs often fall short of meeting their intended objectives of restoring wild self-sustaining natural populations. Although continued habitat problems, limited program scope, duration, and support are often important factors, so too may be the failure to consider a variety of genetic changes associated with the captive rearing of small populations, including the (1) accumulation of inbreeding, (2) loss of genetic variation, (3) accumulation of deleterious alleles, and (4) genetic adaptation to captive rearing conditions. The iBoF LGB program being developed (described below), will hopefully mitigate many of the above genetic changes that could reduce the wild fitness of future generations intended for release into the wild.

Founder broodstock from the two primary LGB populations (Big Salmon and Stewiacke) are collected as either late stage parr or smolt, and brought into Mactaquac and Coldbrook biodiversity facilities, respectively. Individuals are DNA fingerprinted, and crosses prescribed according to the Mean Kinship-based broodstock management program of Ballou and Lacy, that aims to minimize global coancestry in subsequent generations. In addition to minimizing inbreeding and the loss of genetic variation, this strategy may also minimize some forms of among-family selection for captive conditions. Five to ten offspring from each of these crosses will be reared in captivity through to maturity, but the majority of the production will be released as unfed fry into their respective native river habitat (Figure 1). Wild exposed juveniles will be captured as late stage parr

or smolt, brought back into captivity, and reared through to maturity. In the production of the next generation of salmon, crosses will be performed as above, to minimize global co-ancestry, but preference will be given to siblings that have been exposed to wild conditions. This strategy should minimize within family selection for captive conditions in the juvenile or freshwater phase of their life cycle, and reduce the accumulation of deleterious mutations.

Genetic change will be further minimized by cryopreserving semen. Sperm that survive freezing to -196°C (the temperature of liquid nitrogen) remain viable for an estimated 200-32,000 years. Not only do genes within individual frozen spermatozoa remain largely unchanged over this period, but so do the gene pools of cryopreserved gene banks; genetic variation is not lost from the sample, and directional changes in allele frequencies are unlikely to occur. By cryopreserving sperm from the first and second LGB generations, much of the genetic material from the wild founder males and females can be conserved. Use of this material in subsequent generations will not only minimize inbreeding and the loss of genetic variation due to drift (chance changes in allele frequencies), but it is also expected to reduce the accumulation of changes due to selection for captive conditions.

The iBoF LGB program is highly experimental, and there remain many uncertainties as to its efficacy in maintaining genetically variable salmon that retain high levels of fitness to natural conditions. Therefore, research into various aspects of program success, and the efficacy of different management options in use or proposed for inner Bay of Fundy salmon, is being carried out. Different sets of parents spawned in captivity will be used in the production of offspring reared and released (Figure 2) according to various strategies in use or proposed for iBoF salmon. DNA fingerprinting techniques, and parentage or grandparentage assignment of parr, outward migrating smolts, or returning adults will be used to determine whether individuals at various life history stages were produced by (1) remnant wild salmon spawning in river habitat, (2) LGB parents directly in any of the various management strategies outlined in Figure 2, or (3) offspring of LGB parents spawning in the wild. In addition to determining whether observed production is due to remnant wild salmon spawning in river habitat versus LGB salmon spawning in captivity or in the wild, this research may also help evaluate the impact of different management options on survival at various life history stages, and on breeding success in the wild. In addition to providing information to help adapt management strategies for inner Bay of Fundy salmon, this research may also one day benefit a growing list of other endangered Atlantic and Pacific salmon populations identified as being at imminent risk of extinction.

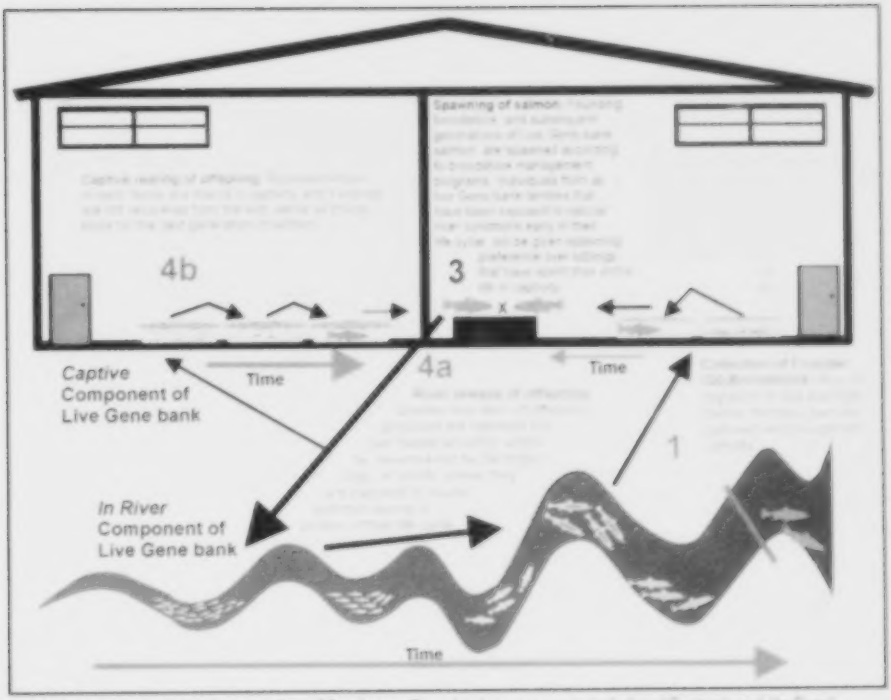


Fig 1. Schematic depicting the inner Bay of Fundy Live Gene banking program, including "Captive" and "In River" components.

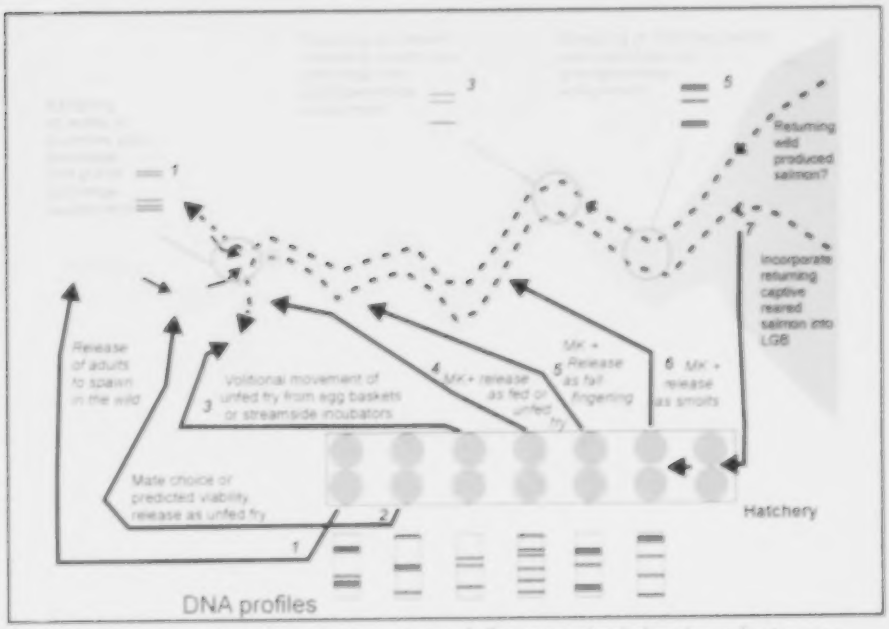

1
2
3
4 MX + release as fed fry
5 MX + Release as fall fingerling
6 MX + release as smolts
7
Returning wild produced salmon?
Incorporate returning captive reared salmon into LGB
Release of adults to spawn in the wild
Volitional movement of unfed fry from egg baskets or streamside incubators
Male choice or predicted viability
release as unfed fry
Hatchery
DNA profiles

Fig 2. Different sets of parents may be used in the production of offspring reared and released according to various management strategies (1-7 above) in use or proposed for iBoF salmon. DNA fingerprinting, parentage and grandparentage analysis of parr, outward migrating smolts, or returning adults may be used to determine whether individuals at various life history stages were produced by (1) wild salmon spawning in river habitat, (2) LGB parents directly in any of the management strategies (listed above), or (3) offspring of LGB parents spawning in the wild.

Marine Plants Research: Diverse Needs in the 21st Century

- Glyn Sharp and Bob Semple

Intertidal seaweed research in the early 20th century revealed a wide diversity and abundance of invertebrates and epiphytes associated with all populations of macrophytes. By the 1980s, the concept that marine plants increase the complexity of the benthic habitat and thereby increase the overall carrying capacity of the coastal ecosystem was well established. Marine plants directly influence water movement, water temperature, light, oxygen, and nutrients in shallow coastal waters.

The marine plant industry in the Maritimes reached a peak of value and development by the 1980s. A suite of three species—Irish moss (*Chondrus crispus*), dulse (*Palmaria palmata*), and rockweed (*Ascophyllum nodosum*)—provided the raw materials for fertilizers, the food additives carrageenan and alginate, and other human food. Surveys had identified the commercially important beds and the methods of harvest were well established. The infrastructure to provide reliable sources of raw materials was put in place by buyers and processors. Fisheries and Oceans Canada marine plant research provided information on basic resource abundance, distribution, and population dynamics. Important fisheries management questions were addressed including the rates of population recovery following harvest and the selectivity and by-catch of harvesting gear. Detailed gear efficiency experiments were conducted in a variety of conditions to determine optimal gear design and harvesting limitations for conservation of the resource. This information contributed to the development of regulations relating to limiting seasons, distribution of effort, and gear impact.

Irish moss drag rake, Miminegash, PEI

The implementation of Canada's *Oceans Act* in 1997 provided a framework to consider the widest implications of habitat disruption in fisheries management plans. Integrated coastal zone management and the ecosystem approach in Canadian fishery policy opened the way for comprehensive management plans in the new harvest of rockweed in New Brunswick. Research by DFO scientists on invertebrate distribution associated with rockweed plants was combined with data on the feeding habits of eider ducks in impacted and unimpacted beds. The gut contents of foraging fishes in the beds was compared to collections of associated invertebrates. This research led to a wide range of precautionary measures for harvesting rockweed ranging from the protection of brooding eider ducks to reducing the impact on habitat structure by adopting low exploitation rates and instituting gear limitations.

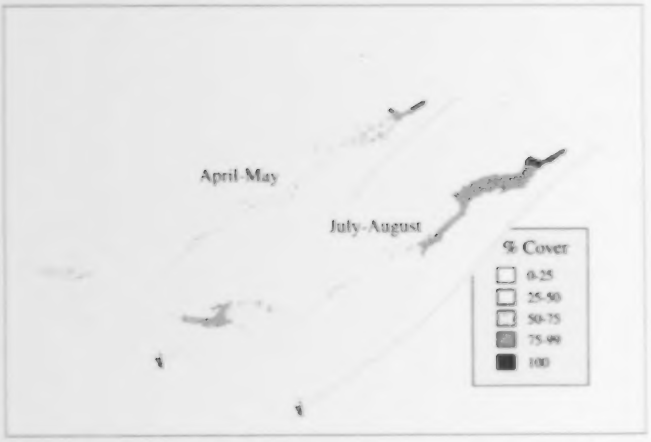
Rockweed habitat and associated animal communities

The demand for biological information on marine plants relevant to fisheries management is constant. A significant challenge arises from human interaction with the coastal ecosystem, particularly in the response of marine plants to environmental degradation. Invasive plant species have direct impacts on coastal aquaculture and indirect effects on coastal habitat. Loss of marine plant habitat due to pollution, grazing, and possibly global warming can affect a range of associated species.

The development of coastal lands for agriculture, habitation, and industry results in direct and indirect inputs to coastal waters, inputs that have major impacts on marine plants. The response of both phytoplankton and macrophytes to enhanced nutrients is rapidly increased production rates, resulting in accumulations of plant biomass called blooms. Blooms can be chemically toxic due to some species of unicellular algae. Macroalgae, primarily green algae (*Chlorophyta*), can reduce the circulation of water in waterways while the breakdown of their tissues can consume oxygen that supports other marine life.

The more diverse research needs for the 21st century have been reflected in recent work of the Marine Plants unit at BIO. The type of research was exemplified during the development of a marine protected area candidate site at Basin Head, Prince Edward Island, proposed to protect a unique strain of Irish moss under the Oceans Act. In 2001-2003, the unit investigated the dynamics of the threats posed by macrophyte blooms in the coastal lagoon ecosystem of Basin Head, a shallow 59 ha lagoon with a 10 m wide entrance.

Basin Head Lagoon, PEI



Percentage of sea lettuce cover in the Basin Head lagoon for the spring period of April-May and the summer period of July-August

Drifting sea lettuce (left) and collection method for drift sea lettuce (right)

A unique unattached population of Irish moss covering 0.7 ha is located in the northeastern arm of Basin Head. The surrounding lands are primarily agricultural and three major streams drain into the lagoon. Nitrate and nitrites are very high in the main basin and phosphates are high in the northeastern arm. Sea lettuce (*Ulva lactuca*) was measured in small growth chambers in the early summer when biomass production reached 30-40% per day. Sea lettuce biomass accumulated rapidly until it dominated the vegetation in the basin in August, after which growth declined in the late summer and tissues degraded rapidly. Tidal flushing of both particulate matter and large pieces of sea lettuce was evident in nets placed in the lagoon entrance.

By mid-October the amount of sea lettuce was less than 10% of the peak biomass. It appears that this particular lagoon environment was able to cope with this marine plant bloom and the protected species, Basin Head Irish moss was not in immediate danger. However, this basin is unique and there are many other nutrient-stressed water bodies in the Maritimes where ecosystem health could be in ultimate decline from similar macrophyte blooms.

This is only one of many ecosystem issues involving marine plants. The demand for further information on the implications of habitat loss, invasive species, and changes in biodiversity will lead the agenda for marine plant research in the 21st century.

BIO Research on Deep-Water Corals in Atlantic Canada

- Pål B. Mortensen, Lene Buhl-Mortensen, Susan E. Gass, Donald C. Gordon Jr., Ellen L.R. Kenchington, Cynthia Bourbonnais, and Kevin G. MacIsaac

Until quite recently, most Canadians did not realize that corals are commonly found off our coasts. The fishing industry has long been aware of their existence because they are frequently caught in bottom-tending fishing gear such as trawls, longlines, and gillnets. Fishers call them "trees". Few scientific studies on Canadian corals have been conducted. However, in 1997 the Ecology Action Centre published a review of the distribution and status of corals off Nova Scotia. The review revealed that several dozen species occur at depths ranging from about 200 m to 1000 m, below the euphotic zone, where their preferred habitat includes hard substrate and significant currents. Nutrition is obtained by filtering food particles from water. The Northeast Channel and The Gully, as well as other locations along the edge of the continental shelf, are identified as key areas for deep-water corals.

In response to concerns about their sensitivity to human activities—in particular, fishing—DFO began studies of deep-water corals in 1997. Initially, data were collected when possible as part of other projects. However, in 2001 the oil- and gas-industry sponsored Environmental Studies Research Fund provided funding for a major three-year research project to provide new information on the distribution, abundance, habitat, and biology of deep-water corals and their associated species in Atlantic Canada.

Data on deep-water corals have been gathered by various means. Valuable information on general distribution has been collected through interviews with fishers, and from the records kept by observers on commercial fishing vessels. Corals are frequently caught in DFO groundfish surveys, and specimens have been sent to BIO for analysis. Live specimens of eight species of soft, horny, and stony corals were collected and have been successfully maintained in the BIO Fish Laboratory. Video footage, photographs, and samples of deep-water corals have been collected on research cruises throughout Atlantic Canada by DFO vessels, primarily the CCGS *Hudson*. Areas visited include the Northeast Channel, the Scotian Slope, The Gully, the Laurentian Channel, and the southern Grand Banks.

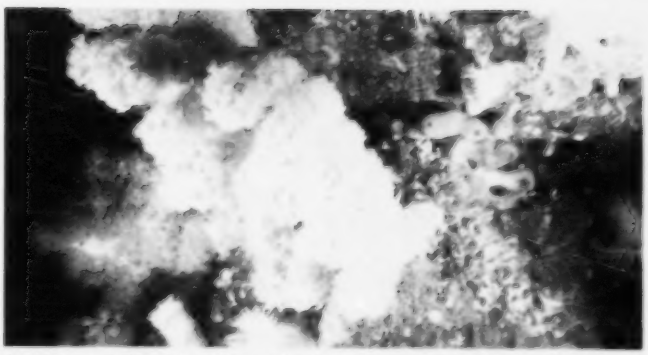
A total of 19 taxa of deep-water corals belonging to five different taxonomic groups (soft corals, horny corals, stony corals, black corals, and seapens) were recorded. The results confirmed the importance of the Northeast Channel and The Gully as key areas for corals. In addition, corals were found to be widespread off Newfoundland and Labrador, and to extend at least as far north as the Davis Strait. An area off Cape Chidley at the mouth of the Hudson Strait could be another prime coral habitat. Large horny corals (for example, sea corn and bubblegum) are especially abundant in the Northeast Channel, while small stony corals flourish along the Scotian Shelf. Horny corals do not build reefs but grow in tree- or bush-like shape. The greatest diversity of coral species occurs in The Gully. The first documented coral reef in Atlantic Canada, made by the spider hazard coral *Lophelia*, was found off the Stone Fence at the mouth of the Laurentian Channel in 2003.

The distribution of deep-water corals is patchy and influenced by several environmental factors including substrate, temperature, salinity, and currents. Larger corals tend to grow on stable substrate such as cobbles or boulders. Smaller corals can grow attached to shells while some can be free-living or anchored in finer sediments. The upper depth limit is thought to be controlled primarily by temperature. Corals are more abundant on the western than the eastern side of the Northeast Channel, The Gully, and the Laurentian Channel, presumably due to higher concentrations of food particles in outflowing water.

The bubblegum coral tends to be the largest horny coral. In the Northeast Channel, colony height ranges from 5 to 180 cm. One specimen collected in the Flemish Pass off Newfoundland was at least 300 cm in height. Growth rates of horny corals have been determined to be in the order of 1 to 4 cm/year. Therefore, the ages of the colonies observed are in the range of tens to hundreds of years.

Horny corals have been found to host a rich associated fauna dominated by suspension feeders that use the colonies as a platform for feeding and/or a refuge against predators. Coral branches reach up

Paragorgia arborea (bubblegum coral) and Acanthogorgia armata, taken using Campod at 460 m in the Laurentian Channel (2002)



Primnoa resedaeformis (sea corn coral) with sea anemones and a soft coral, taken using Campod at 280 m at the Stone Fence near the mouth of the Laurentian Channel (2003)

into the stronger currents above the calmer near-bottom environment. This increases the supply of food particles to the coral, an advantage that is also used by the associated fauna. Various species of fish are commonly seen associated with corals in the video imagery, the most common being redfish. The abundance and diversity of associated fauna is significantly correlated to host morphology. Large and old colonies house more associates than small and young colonies. The invertebrate fauna is richer than that of tropical shallow-water horny corals. Most of the associated species can also occur in other deep-water habitats. Parasitic anemones and copepods have been identified.

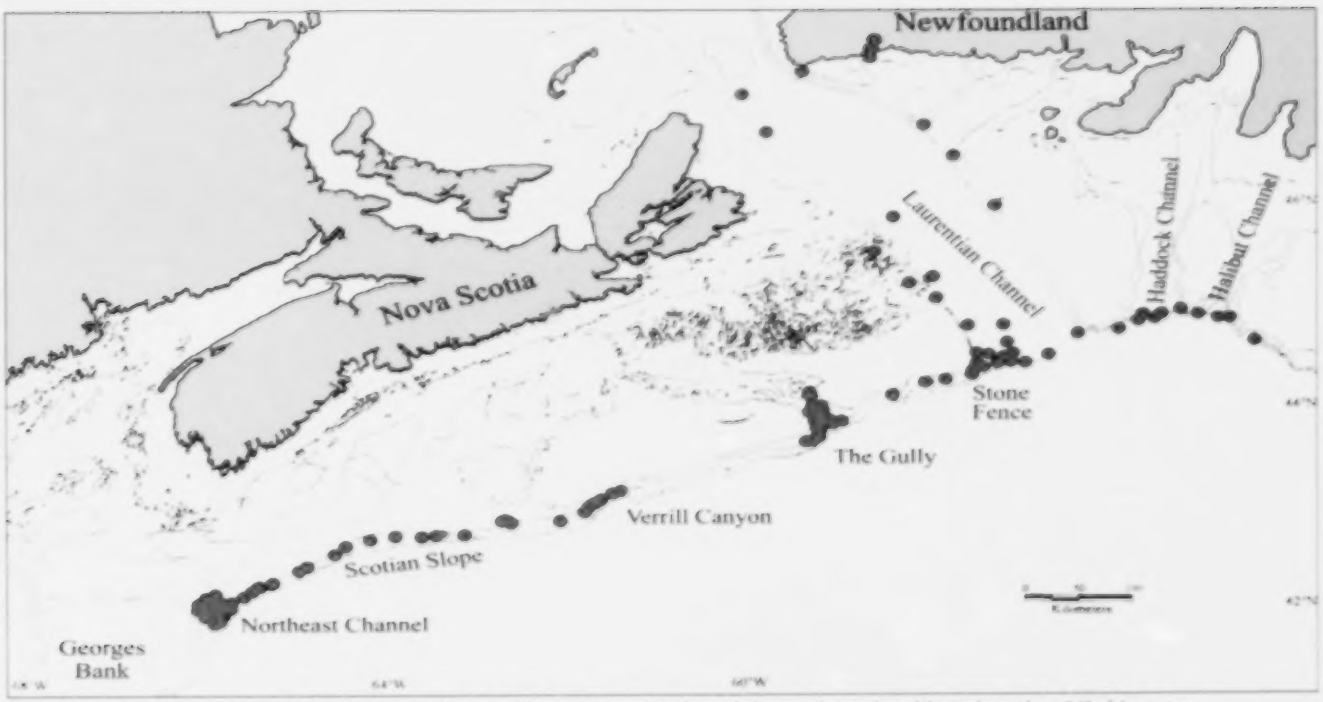
Lophelia pertusa (spider hazard coral) with a redfish taken using Campod at 280 m, at the Stone Fence near the mouth of the Laurentian Channel (2003)

Because of their large size, arborescent growth form, and fragile nature, deepwater corals are particularly sensitive to damage from bottom-tending fishing gear. Recovery from any damage will take a long time because of their slow growth rates. Fishing damage was observed to be heavy at the Stone Fence reef. Live *Lophelia* colonies were either small or clearly broken in an unnatural way, and the rubble zone was larger than observed at similar-sized reefs off Norway. Many cobbles and boulders showed signs of being overturned, with horny corals growing unnaturally on the sides or underneath. A fragment of trawl net was observed.

Fishing damage was seen also in the Northeast Channel. In total, 4% of the observed coral colonies were damaged, and damaged corals were observed on 29% of the 52 video transects. Lost gillnets and longlines, loose on the seabed or entangled in corals, were evident, as well as tracks in the seabed from fishing gear. Very few indications of fisheries damage were observed in The Gully and none on the Scotian Slope.

Deep-water corals have captured the imagination of the Canadian public, in part because of extensive media coverage. Led primarily by environmental organizations and universities, a strong conservation movement has developed in Canada to protect deep-water corals from human activities. The results of the BIO coral studies have been used by DFO to design and implement protective measures for important deep-water coral habitats in Atlantic Canada. In 2002, DFO established a 424 km² coral conservation area in the Northeast Channel that excludes trawlers from 100% of the area but allows longliners in 10%. DFO is in the final stages of establishing The Gully as a Marine Protected Area that will include restrictions on fishing and hydrocarbon activities. Consultations are underway with the fishing industry regarding the design of a closure at the Stone Fence to protect the newly discovered *Lophelia* reef and provide opportunity for its recovery.

While information on these fascinating organisms is growing rapidly, there is still much to learn about them. More video surveys are needed to determine deepwater coral distribution and abundance, particularly in areas predicted to be prime habitat. Because of limitations of sampling gear, there is little information on corals growing deeper than 500 m. It is important also to study the effectiveness of the conservation areas being established to ensure they are fulfilling their purpose in protecting corals and allowing habitat recovery from past damage.



Map indicates the locations where corals have been looked for since 2001, with Campod (video and photography), on board the Hudson. About 2/3 of the stations had deep-water corals.

Contaminated Harbours

- *Phil Yeats and Kenneth Lee*

The level of anthropogenic chemical contaminants in our coastal waters has decreased substantially over the past few decades as a result of increased knowledge of chemical pollution, improved regulation, enforcement of waste discharges, and increased environmental consciousness of industry and the general public. Dilution as the solution to marine pollution is no longer considered a viable option. Nevertheless, some harbours and estuaries in Canada continue to receive substantial discharges of toxic chemicals at levels that may have detrimental effects on the marine ecosystem. There is also potential for harm from remobilization of sediments contaminated in earlier, less enlightened times.

Our ongoing investigation of waste discharges to the harbours and estuaries of the Maritimes Region is focused on identifying the primary toxic chemicals of concern and developing an understanding of the processes controlling their distribution, fate, and effects. Most of the work has been conducted in the ports of Halifax and Sydney. In common with other major industrial, transportation, and population centres, these sites have been the depository of industrial and anthropogenic contaminants during the 20th century. In particular, our current research has focused on the impacts of discharges from the Sydney Tar Ponds on Sydney Harbour and on sewage on both harbours. We have described: 1) distribution and fate of some of the contaminants currently being discharged to the harbours, 2) historical inputs of contaminants as recorded in marine sediment cores, 3) ecological effects of the exposure to these contaminants, 4) natural recovery processes, and 5) predictive models of contaminant transport and fate.

Subsampling of sediment cores by Grazyna Folwarczna and Rick Nelson for dating and contaminant analyses. as recent sediments are generally deposited on the surface, we can determine changes in contaminant concentrations over time.

DISTRIBUTION AND FATE

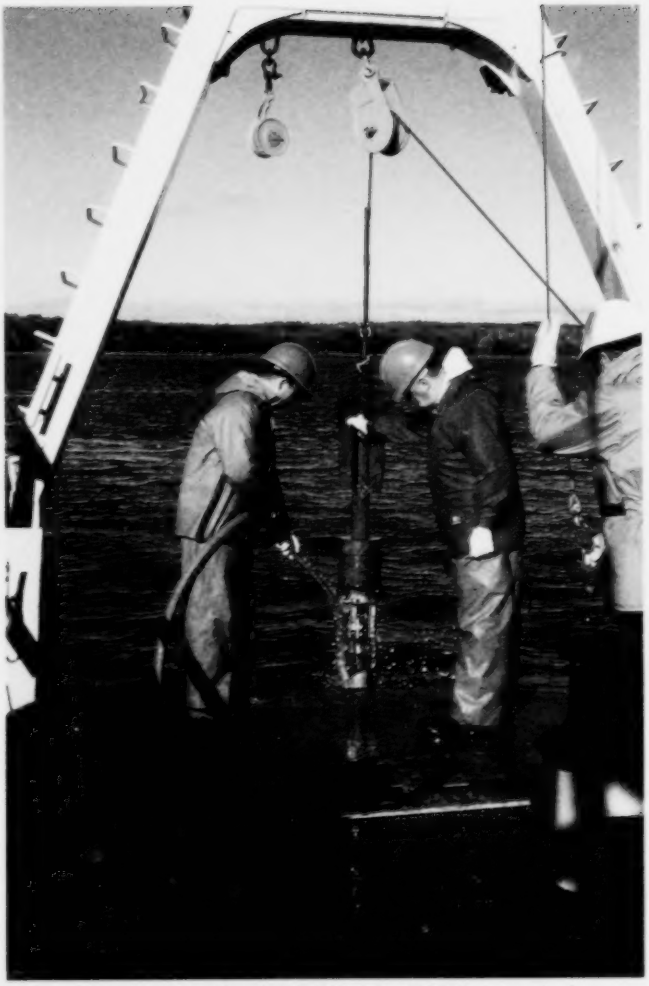
Samples of sediments, water, and biota have been collected from Halifax and Sydney harbours and approaches to determine contaminant concentrations and their distribution within the marine environment. Both organic and inorganic contaminants from industrial and municipal sources have been detected. In Sydney, elevated levels of polycyclic aromatic hydrocarbon (PAH) and polychlorinated biphenyl (PCB) in sediments have been identified as the major contaminants of concern. For inorganic contaminants, measurements of heavy metal concentrations in the water reveal concentrations that are similar to those in other less contaminated harbours, but in some areas of both harbours, the sediments contain levels of metals exceeding the environmental quality guidelines of the Canadian Council of Ministers of the Environment. Toxicity Identification and Evaluation (TIE) studies have been conducted with Halifax Harbour samples to identify the most toxic components of concern in sewage discharges.

HISTORICAL INPUTS

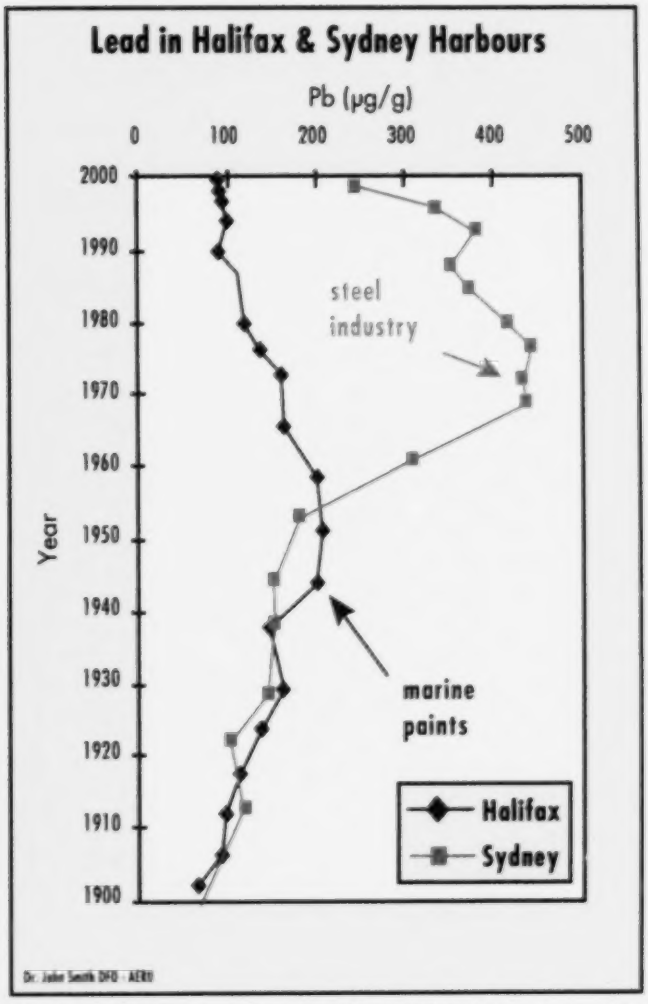
Analyses of ^{210}Pb and ^{137}Cs were conducted along with analyses of PAHs, PCBs, and metals in samples from sediment cores recovered from the harbours to determine a historical record of contamination and to predict the rates of natural remediation by sediment burial. In Sydney Harbour, results correlated industrial development of the region with some metals, such as lead and PAHs, reflecting the history of coking operations associated with the steel industry. It is interesting to note that the highest contaminant levels are now found at 10-30 cm depth in the sediments, as less contaminated sediments are now being deposited in the harbour with the closure of the steel plant. As a result, future remediation efforts must consider the possibilities for recontamination of surface sediments, which have effectively capped the main inventory of contaminants.

NEGATIVE ECOLOGICAL EFFECTS

Seabed animals 0.5 mm and larger, known as benthic macrofauna, were recovered from the harbours to determine their state of health,



Recovery of a sediment core from Sydney Harbour by Rick Nelson, Jim Abriel, and a Navicula crew member



Distribution of lead (Pb) in sediments recovered from Halifax and Sydney harbours Note the historical correlation between contaminant concentrations with the onset of industrial (steel industry operations – Sydney Harbour) and commercial shipping operations (use of marine paints – Halifax Harbour).

their contaminant levels, and their distribution patterns relative to contaminant levels within their habitat. Laboratory studies with sediments recovered from Sydney Harbour have shown detrimental effects on amphipods as a result of exposure to PAHs. A study of contaminants and biological effects in mussels in the central part of the Halifax Harbour, which is in the vicinity of major sewage discharges, has shown elevated levels of contaminants (PAHs, copper, tin, and silver) and reproductive effects.

NATURAL RECOVERY PROCESSES

With our evidence on the decline of contaminant inputs into the environment, focus has shifted to quantifying natural recovery rates. To achieve this objective, several study components were designed to determine the removal rates of contaminants from the system. Analyses by physical oceanographers and sedimentologists in the program have verified that physical processes such as tides and currents contribute to the transport of contaminants from the harbours. Despite elevated concentrations of contaminants, microbiological studies showed an abundance of bacteria within all sediment samples recovered from the harbours. Radiotracer studies quantifying their rates of metabolic activity and analysis of gene sequences have confirmed their potential to degrade many of the PAH compounds of environmental concern. To further illustrate the extent of the natural recovery, a comparison of data on the benthic species community structure from this study is being made to past studies.

APPLICATION OF MODELS AND THE FUTURE

Our studies have documented the improvements to environmental quality over the past decades as contaminant inputs have decreased. Nevertheless, they have also shown that negative ecological impacts of current and past inputs continue to exist. With the data collected under this program and our improved understanding of natural processes controlling contaminant fate and transport, predictive mathematical models have been developed. These models will be of use to environmental resource managers within DFO and other environmental interest groups to help them predict the impacts of changes in contaminant inputs and assess the potential benefits of various proposed remedial activities relative to natural recovery.

Working Together to Identify and Protect Maritime Coastal Habitats for Future Generations

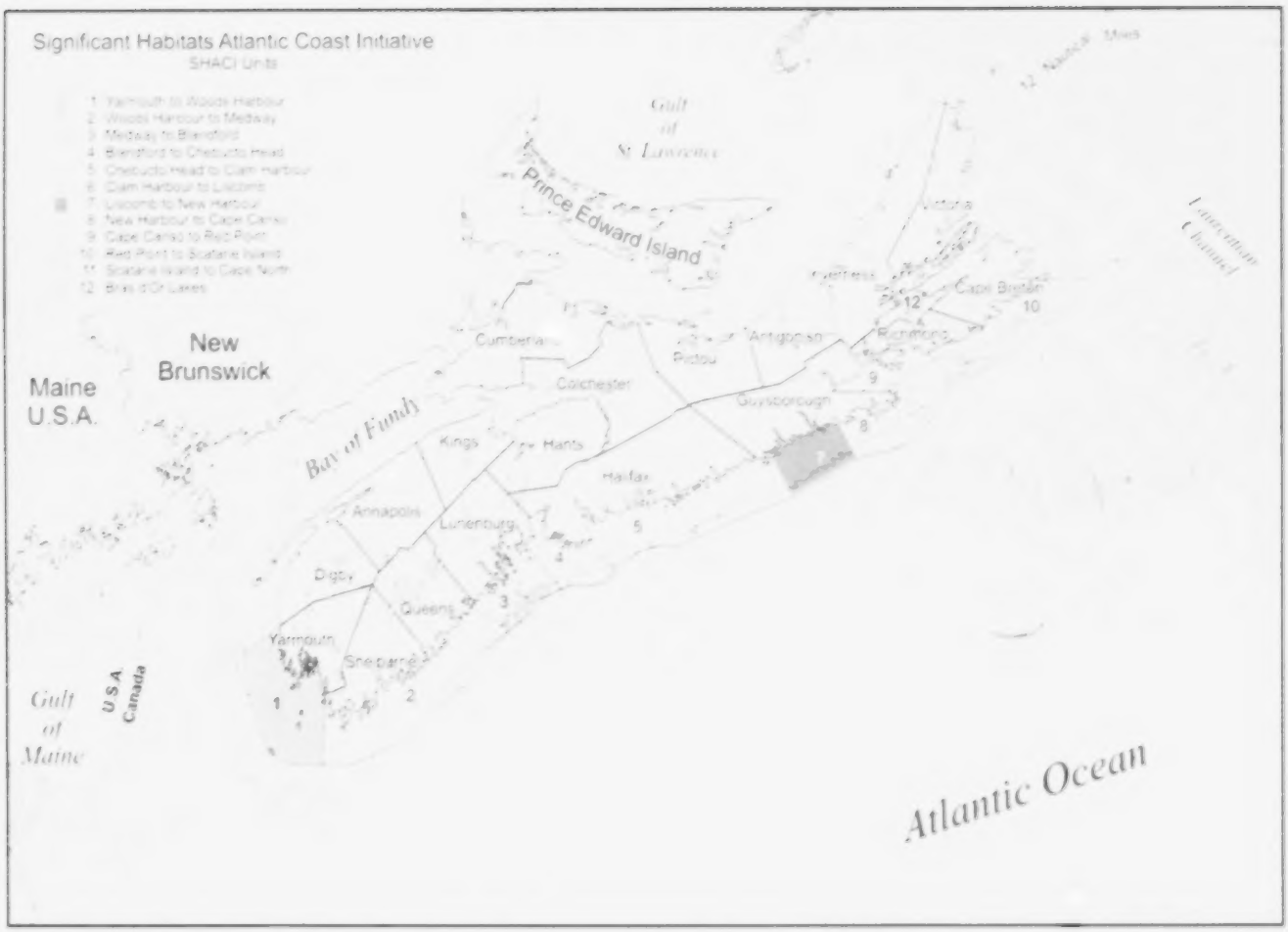
- Dave Duggan

Coastal habitats—those habitats making up the shoreline strip of shallow water and the lands immediately adjacent—are among the most diverse and productive ecosystems in the world, and perform vital ecological processes. Coastal habitats can include areas of shallow marine water, rocky shorelines, estuaries, marshes, sand, mudflats, eelgrass beds, kelp beds, and intertidal algae.

The habitats support populations of fish, birds, and other wildlife that are often nationally or internationally significant. However, they tend to be also centres of human population settlement and resource development. Urban expansion, fishing, milling, and other resource-based activities have contributed to loss of estuarine and other wetlands, and population relocation continues to threaten the remaining coastal habitats.

As coastal communities seek to expand and diversify their economies, and competition for coastal space increases—partly as a result of downturns in traditional resource-based activities—it becomes vital to ensure that new growth and development is environmentally sustainable and is directed to areas of low sensitivity.

Over the years, many calls for improved coastal zone management in Canada have come from a broad range of groups. The Coastal Management Section of the Oceans and Coastal Management Division (OCMD) is responsible for tracking and monitoring developing coastal activities in the Maritimes Region to ensure protection of sensitive marine areas and their integration into coastal management plans. OCMD is engaging and partnering with stakeholders to achieve integrated planning and management of coastal zone activities by applying Canada's Oceans Act's principle-based approach, which coastal states around the world are also working to implement: integrated management, sustainable development, ecosystem-based management, and precautionary and collaborative approaches. DFO is developing collaborative arrangements with the provinces and territories and with key stakeholders



Working Together to Identify and Protect Maritime Coastal Habitats for Future Generations

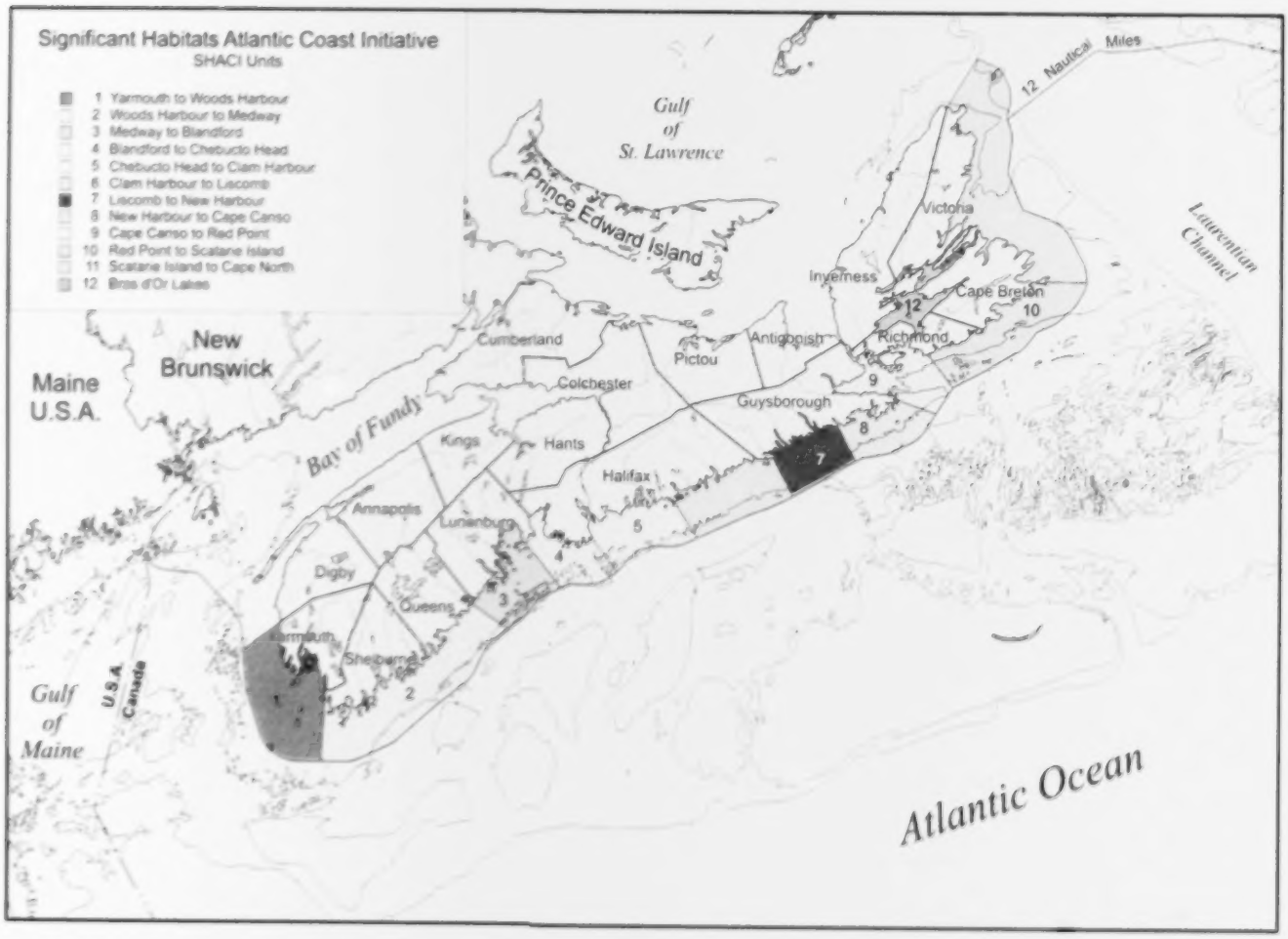
- Dave Duggan

Coastal habitats—those habitats making up the shoreline strip of shallow water and the lands immediately adjacent—are among the most diverse and productive ecosystems in the world, and perform vital ecological processes. Coastal habitats can include areas of shallow marine water, rocky shoreline, estuaries, marshes, sand, mudflats, eelgrass beds, kelp beds, and intertidal algae.

The habitats support populations of fish, birds, and other wildlife that are often nationally or internationally significant. However, they tend to be also centres of human population settlement and resource development. Urban expansion, dyking, infilling, and other resource-based activities have contributed to loss of estuarine and other wetlands, and population relocation continues to threaten the remaining coastal habitats.

As coastal communities seek to expand and diversify their economies, and competition for coastal space increases—partly as a result of downturns in traditional resource-based activities—it becomes vital to ensure that new growth and development is environmentally sustainable and is directed to areas of low sensitivity.

Over the years, many calls for improved coastal zone management in Canada have come from a broad range of groups. The Coastal Management Section of the Oceans and Coastal Management Division (OCMD) is responsible for tracking and monitoring developing coastal activities in the Maritimes Region to insure protection of sensitive marine areas and their integration into coastal management plans. OCMD is engaging and partnering with stakeholders to achieve integrated planning and management of coastal zone activities by applying Canada's *Oceans Act*'s principle-based approach, which coastal States around the world are also working to implement: integrated management, sustainable development, ecosystem-based management, and precautionary and collaborative approaches. DFO is developing collaborative arrangements with the provinces and territories, and with key stakeholders



such as First Nations, coastal communities, and industry and non-governmental organizations.

As part of this engagement, the Significant Habitats Atlantic Coast Initiative (SHACI) is a project aimed at identifying, mapping, and documenting significant coastal habitats along the Atlantic Coast of Nova Scotia. The coastal areas included in SHACI extend from Yarmouth on the southwest shore to Cape North on the northern coast of Cape Breton Island, including the Bras d'Or Lakes, and from the high tide mark to the 12-nautical-mile offshore limit of Canada's Territorial Sea. OCMD is undertaking this initiative primarily to contribute to programs being developed under the Oceans Act for the nearshore Atlantic coast region.

The maps and reports produced through SHACI are intended for use by a general audience including ocean planners, fisheries managers, non-government organizations, consultants, industry, and the public for purposes such as public education, coastal planning, resource management, and environmental assessments.

DFO recognizes that natural resource interests such as the forestry, fishing, mining, energy, and agricultural sectors make legitimate demands on water resources, and that ways must be found to reconcile differences of opinion on the best use of those resources. Effective integration of resource sector objectives, including fisheries, will therefore involve cooperation and consultation with other government agencies and natural resource users. Fish habitat management objectives on a local or regional basis may be implemented through Integrated Resource Management plans for these various sectors. Canada's Fish Habitat Management Program is a key component of DFO's commitment to conserve and protect fish and fish habitats from the adverse effects of development conducted in or near water. Under this program, DFO strives to balance unavoidable habitat losses with habitat replacement or compensation to achieve "no net loss" of fish habitat.

All stakeholders, including the various levels of government, recognize the need to commit to an active program to work out jurisdictions collaboratively. In some cases, these involves using existing processes and in others it will involve "writing the rules" for working together, including the broader community. Formal arrangements may be put in place as required to effectively implement the coastal zone programs. In support of this priority, OCMD has begun working formally with provincial and municipals governments to develop working relationships. Next steps include engaging the broader community in the initial stages of the development of coastal management plans.

Coastal zone planning and management is about developing sustainability, which involves social, economic, environmental, and institutional components. Not only is it about protecting the environment or finding out how to economically develop without impacting the environment, it is an effort that will provide security to our coastal communities and the marine environment on which they depend.

If future generations are to enjoy healthy, productive, and biologically diverse coastal ecosystems, it is essential to prevent their further loss and degradation. This means better managing coastal habitats as well as the watersheds that sustain them—a responsibility shared by all.

Nature's Silly Putty: 200 Million Years of Salt Deformation and Sediment Deposition

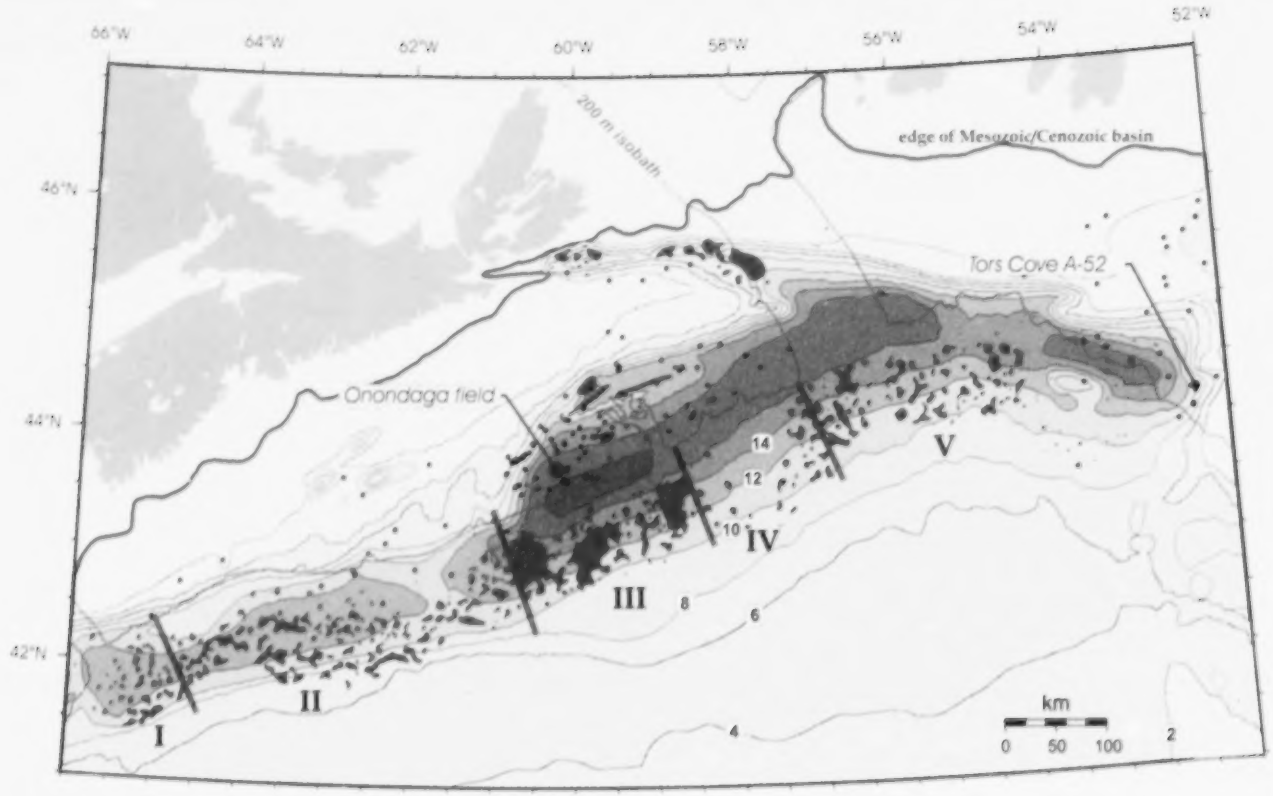
– John Shimeld

The first offshore well drilled in the search for oil and natural gas in the Scotian Basin was Tors Cove D-52 in 1966. The drilling location was chosen on the basis of seismic reflection data that revealed 1200 m of uplifted strata forming an anticline (a convex-upward fold) above an upright, roughly cylindrical mass of salt known as a diapir. Salt comprising the diapir originated from the more deeply buried Argo Formation which, in this region of the basin, is covered by about nine kilometers of sedimentary rocks. Since 1966, hundreds of salt diapirs, exhibiting a fascinating array of geometries, have been discovered and mapped throughout the Scotian Basin using seismic reflection data. Salt diapirs are also widespread beneath the Grand Banks of Newfoundland, the Gulf of Saint Lawrence, and regions of New Brunswick, Nova Scotia, and Prince Edward Island.

Salt diapirs create many favourable geometries for entrapment of oil and natural gas. Indeed, a significant proportion of the world supply is tapped from geological structures directly associated with salt diapirs, so it is not surprising that they are attractive exploration targets in Atlantic Canada. It is surprising, though, that the mechanisms responsible for their creation and growth were discovered so recently, especially considering the importance of salt diapirs not just to the oil industry, but also to the mining and chemical industries. Even the nuclear industry has given serious consideration to disposal of radioactive waste in salt diapirs, so it is important to understand how salt deforms and why diapirs exist. [1]

Since salt that is buried deeper than 1.5 to 2.0 km is less dense than the overlying sedimentary rocks, the prevailing hypothesis, until the mid-1980s, was that buoyancy forces cause the salt to rise vertically, in a viscous manner, intruding and uplifting the overlying layers. By the late 1980s, serious challenges to this theory were posed by technological advances in seismic imaging of the subsurface that showed previously unsuspected relationships between diapirs and surrounding rocks. During the same time, exploration drilling in heavily explored regions like the Gulf of Mexico confirmed the existence of tabular, subhorizontal salt bodies that have been termed canopies. Some canopies cover thousands or even tens of thousands of km^2, are completely detached from their source layer ten or more km below, and have moved laterally from 50 to 100 km.

[1] Salt mines currently operate in Nova Scotia, New Brunswick, and the Magdalen Islands.



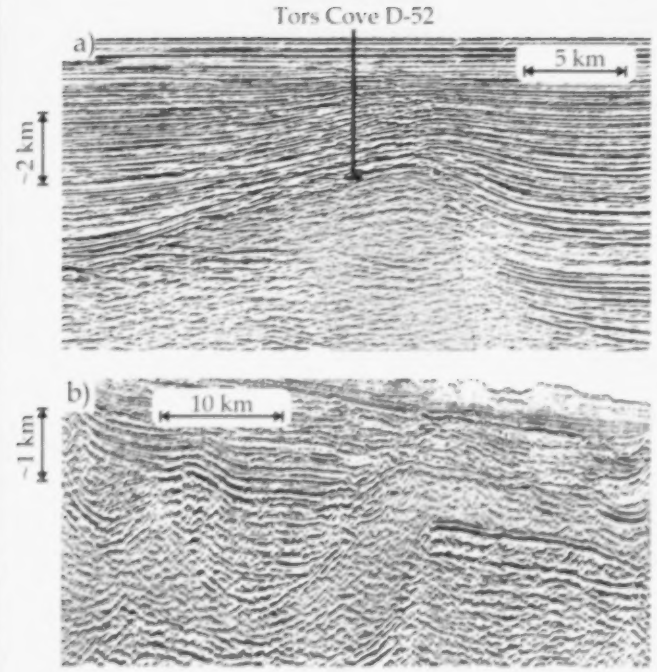
This is a map of the thickness (in km) of Mesozoic and Cenozoic sediments within the Scotian Basin. Shallowly-buried salt diapirs are indicated by purple polygons. Five distinct zones are defined beneath the deep water region on the basis of diapiric styles and sedimentation patterns. The present-day 200 m isobath (blue line) marks the edge of the continental shelf. Well locations are indicated by the black dots. Tors Cove D-52 was the first exploratory well drilled in the Scotian Basin.

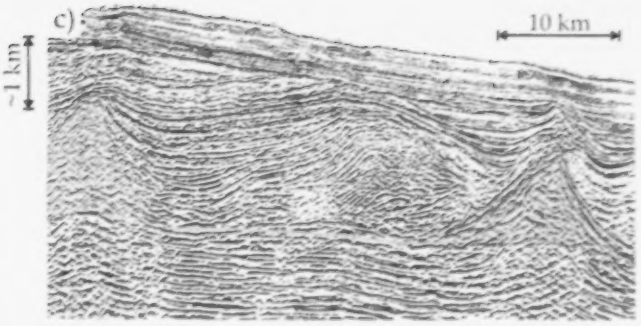
Vertical buoyancy forces do not explain lateral movement of salt. It is now understood that salt deforms in a plastic manner—like silly putty over geological timespans—under the influence of even relatively small differential loads. This happened within the Scotian Basin, during the Jurassic and Early Cretaceous periods (from about 200 to 100 million years ago), as rivers carried sediment from the eroding Appalachian mountains in the west and northwest, and deposited it in a seaward tapering wedge along the margin of the nascent North Atlantic Ocean. The ocean had formed in response to rifting of Pangea, the supercontinent that split to eventually become Africa and North America. During the rifting process, which began some 20 million years earlier in the Late Triassic, shallow saline lakes and inland seas evaporated vigorously under the influence of a hot and arid climate, and that left behind extensive deposits of salt, perhaps as much as one to two kilometers thick in some regions (the general setting was similar to the modern rift system that extends southeastward from Jordan, beneath the Red Sea, and southward along the African Rift Valley between Ethiopia and Mozambique). Thus, once continental rifting had finished and the Atlantic Ocean began to form in the Jurassic, the tapering wedge of sediment was deposited on top of the salt. At a regional scale, this created a differential load that caused the salt to be expelled both vertically and laterally.

Myriad diapir and canopy geometries are the result of variations in the pattern of sedimentation and differential loading. Almost as soon as sediments accumulate on top of it, a salt layer will begin to deform. Loci of deposition form naturally in seafloor lows and, as sediments accumulate there, the differential load affecting the underlying salt increases. This forces salt from beneath the depositional centres and into adjacent diapirs. Growth of the diapirs keeps pace with and directly influences the sedimentation, at least until the source layer of the salt is depleted. Such revelations, during the late 1980s and early 1990s, significantly altered hydrocarbon exploration concepts and strategies for the many sedimentary basins around the world where salt diapirs exist.

While these concepts were being developed elsewhere, exploration activity within the Scotian Basin had come to a near standstill. In 1998, a new cycle of exploration began, focused primarily on the continental slopes of eastern Canada in water depths ranging between 200 and 3500 m. In the Nova Scotian jurisdiction, for example, companies have committed $1.5 billion to explore 70,000 km^2 of licensed holdings over the continental slope. Since 1998, several hundred thousand km of modern seismic reflection data have been acquired in the deep water region which, not coincidentally, overlies the highest concentration of salt diapirs within the Scotian Basin.

The deep-water is truly a frontier region: only 11 exploratory wells have been drilled (compared with a total of 134 exploratory wells for the entire basin). So little is known about the geology that publicly available maps, like those published in 1990 by the Geological Survey of Canada, are highly conceptual or even blank for the deep-water region of the Scotian Basin. To fill the gaps, GSC





a) This is a seismic reflection image of the diapiric structure that, in 1966, prompted drilling of Tors Cove D-52, the first exploratory well in the Scotian Basin. Salt is indicated in purple. Only minor amounts of natural gas were detected but, three years later, gas was discovered in the same basin, above the crest of a salt diapir, 20 km southwest of Sable Island, at the Onondaga field.

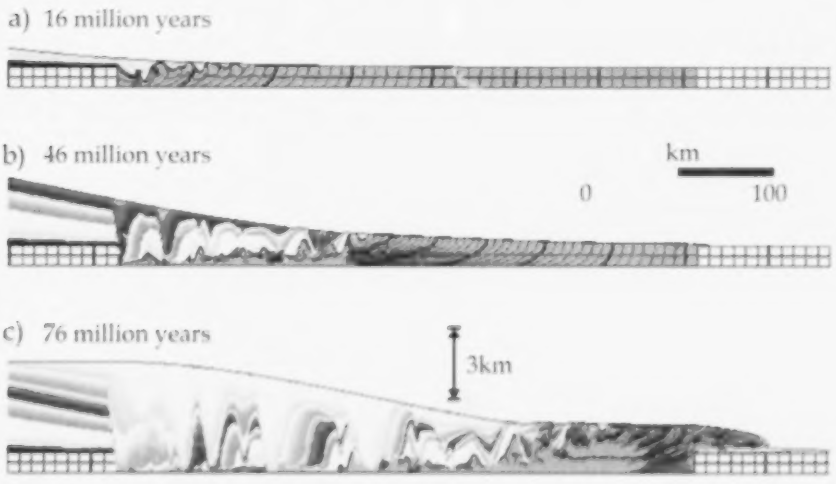
b) Modern seismic reflection data clearly show the presence of a salt canopy that has moved both vertically and laterally seaward due to differential loading by sediments.

c) Continual interaction between sedimentation and salt deformation has created these structures which are highly attractive for hydrocarbon exploration.

Atlantic researchers are interpreting 34,000 km of high quality seismic reflection data acquired during 1998/9 by a company named TGS-Nopec. These data allow, for the first time, an assessment of salt sediment interaction in the basin using the modern insights gained elsewhere.

As a result of the project, five distinct zones have been defined beneath the deep water region, among which there are significant differences in the morphology of the diapirs and the pattern of sedimentation. The differences are linked to regional variations in sediment flux to the basin through time and have important implications for oil and gas exploration. The growth history of individual diapirs also provides valuable clues that can help to unravel the constant interplay between regional subsidence or uplift and global fluctuations in sea level and climate throughout the evolution of the Scotian Basin. These insights will underpin future geological models of the nature and distribution of hydrocarbon reservoirs and seals in the deepwater region.

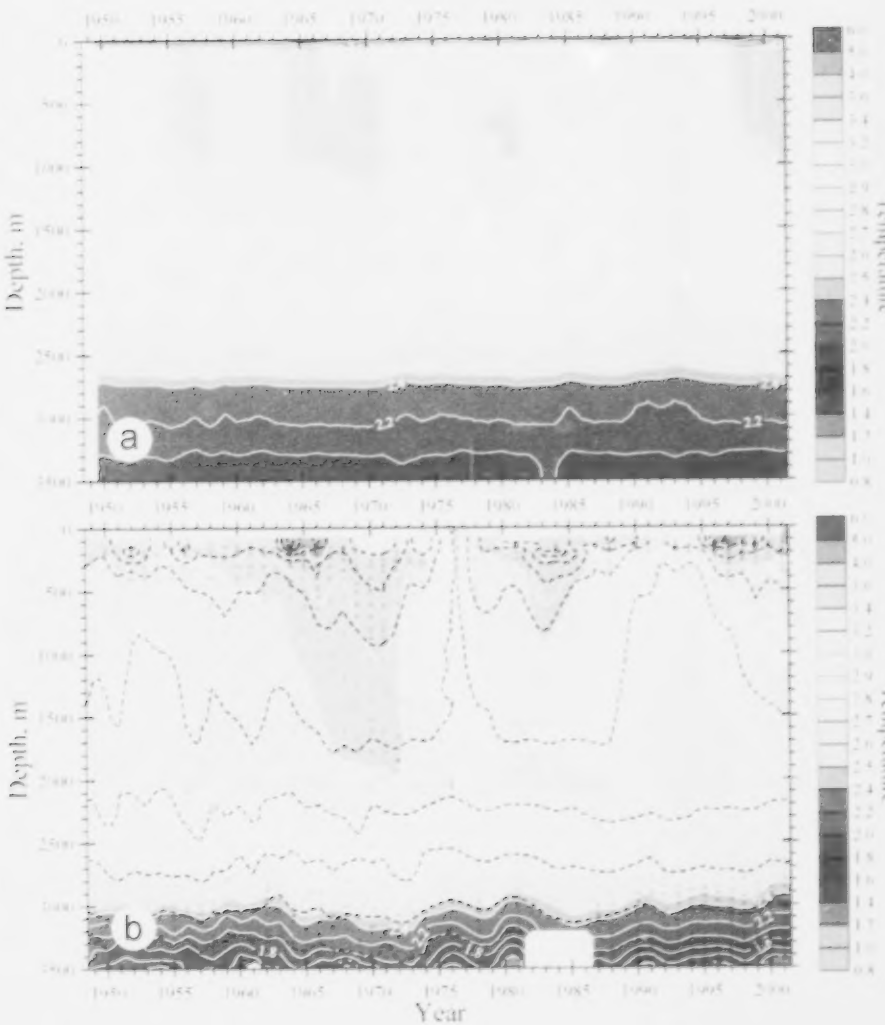
Interpretations produced by GSC Atlantic researchers provide regional context for companies that focus on site specific assessments of hydrocarbon potential within their licence holdings. The Minerals Management Service of the U.S. Department of the Interior is also using the latest GSC Atlantic interpretations for their comparative basin studies and global resource assessments. Federal/provincial regulations, enacted through the Canada Nova Scotia Offshore Petroleum Board, stipulate that the seismic data are confidential until 2008/9. However, through a research agreement signed in 2001 with the data owner (TGS-Nopec), GSC researchers have received permission to publish numerous aspects of their research. Half a dozen oral and poster presentations have been given at various local, national, and international conferences, and a manuscript has been accepted for a special publication of the 24th annual Bob F. Perkins Research Conference on Salt Sediment Interactions to be held in Houston in December 2004. The data continue to be valuable for GSC projects on basin assessment, geo hazards, and gas hydrates, and have helped to create important links with academic researchers.



These are three frames from a numerical model created to simulate the interaction between sedimentation and salt deformation. The model is being developed by Ph.D. candidate Steven Ings, with guidance from GSC Atlantic researchers and members of the Dalhousie University Geodynamics Group headed by Dr. Chris Beaumont. Notice that the salt, shown in purple, begins deforming as soon as it experiences differential loading. Many of the geometries seen in this model closely resemble structures that have been mapped in the Scotian Basin using modern 2-D seismic data.

Ocean Circulation Modelling

Don Wright, Youyu Lu, Igor Yashayaev, Alain Vezina, and Svetlana Losa



North Atlantic Circulation Modelling

- Dan Wright, Youyu Lu, Igor Yashayaev, Alain Vezina, and Svetlana Losa

Observational programs over the past several decades have made major contributions to the description of the mean state and variability of ocean circulation. However, the oceans are both difficult and expensive to observe. They are vast in extent and important changes occur on spatial scales extending from centimeters to thousands of kilometers and on time scales extending from seconds to thousands of years. Adding to the challenge, these disparate scales are coupled through nonlinear processes so that the changes occurring at the largest space and time scales are influenced by processes that happen at the smallest scales.

While observations will remain sparse in both space and time for the foreseeable future, computerized models can provide an additional source of information for ocean studies. The essential idea of such models is to divide the ocean into many boxes (or cells) and formulate mathematical equations to represent exchanges of momentum, heat, salt, and mass among these cells. These equations are then solved using computer software to provide an internally consistent representation of how the ocean evolves. The models can be used to help interpret and fill gaps in the limited observations, to test and extend theoretical studies of ocean dynamics, and to provide predictions of future changes. They can be used to improve short-term weather and long-term climate change predictions that directly impact our living conditions on land, and can provide information on present and future oceanic conditions of interest to the energy, fishery, and ocean transportation sectors.

Modelling the ocean presents many challenges. Although the oceans are large and their variability extends to small scales, computer resources limit the number of cells that can be used to represent the system, so we must limit the size of the domain considered as well as the minimum scales resolved by a model. Each of these economies has drawbacks. Limiting the number of model cells means that approximate formulae must be used to represent the effects of unresolved processes in terms of quantities that are resolved. Limiting the size of the domain requires that conditions at the artificial boundaries be specified to represent the effects of the regions outside the modelled region. We must also specify initial conditions and forcing fields that are each known only approximately.

As a consequence of the various model limitations, verification is a necessary step in the development and application of any ocean model. This requires appropriate data for comparison with the model results. Below, we briefly discuss two examples of comparisons between model and data products that not only test the validity of model results but also help us to better understand the significance of the observations. The first involves observations of water mass properties in the North Atlantic, while the second involves observations of biological properties in the same region. In each case we

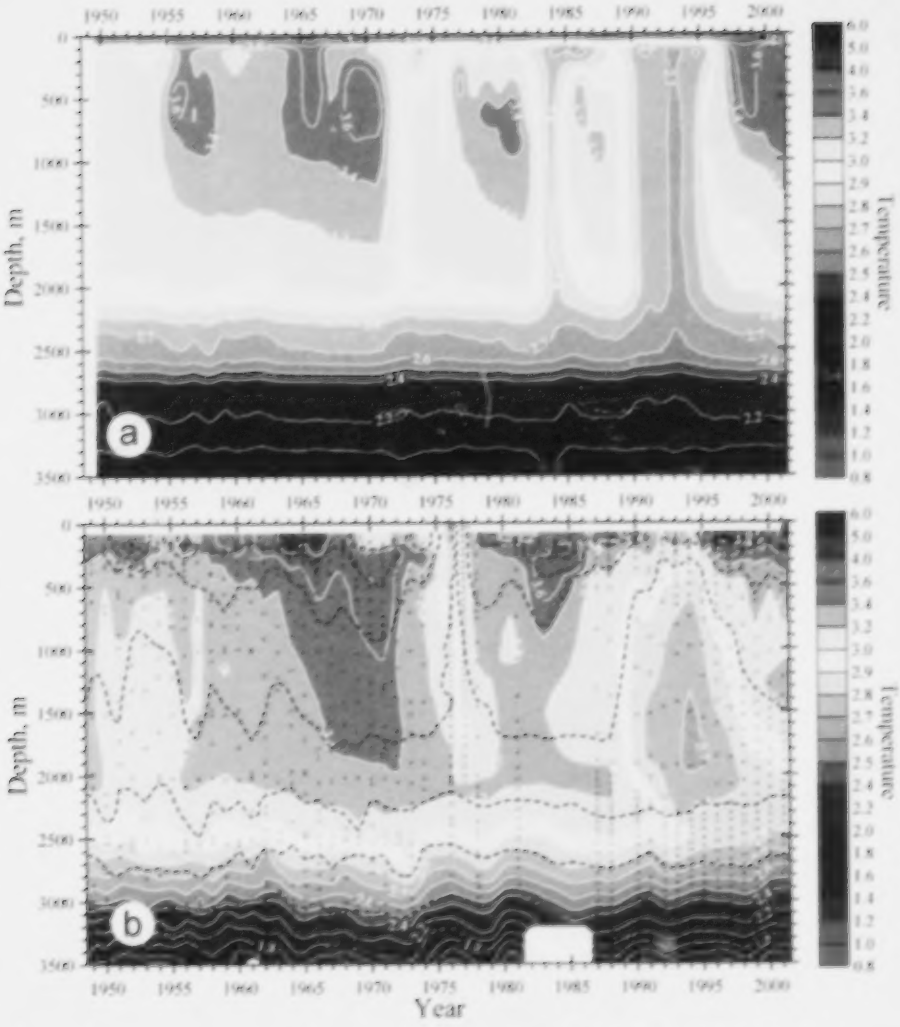


Figure 1. Panels a and b show, respectively, the model and observational estimates of the temperature in the central Labrador Sea from 1949 to 2001. The successful simulation of the decadal variations tells us that the model currents and mixing processes are reasonably represented, and encourages us to use it to investigate the processes controlling primary production in the North Atlantic.

will be concerned with basin scale variability on time scales extending from years to decades.

We use the Parallel Ocean Program computer code that was developed at the Los Alamos National Laboratory, and model simulations done at Dalhousie University on facilities supported through the activities of the Center for Marine Environmental Prediction. Our model domain covers the Atlantic Basin from 30° S to 70° N, and from the surface to 5500 m depth. The size of the individual cells used to represent the ocean varies from 115 km x 115 km at the equator to about 38 km x 38 km at the northern extremity of the basin, and from 10 m thickness at the surface to 500 m thickness below 3000 m depth. The model is forced with estimates of the momentum, heat, and fresh water fluxes produced by the U.S. National Centers for Environmental Prediction reanalysis project plus observed oceanic conditions at the northern and southern boundaries.

Figure 1a shows the model estimates of the temperature in the central Labrador Sea from the surface to the bottom over the period from 1949 to 2001. These results can be compared to Figure 1b, the observational estimates of the temperature variations for the same location and time interval, extracted from a database developed by BIO's Dr. Igor Yashayaev. This database is a product of the long-term investment in observational programs by DFO and other oceanographic institutions around the world. The variations in deep-water properties are of great interest to researchers (including ourselves) interested in large-scale ocean dynamics and the ocean's role in long-term climate change, but we will focus on the variations in the upper ocean due to the relevance to the biological problem discussed next.

The agreement between Figures 1a and 1b is encouraging. In both the model results and the observations, there are periods of several years during which the temperature is nearly uniform from the surface down to a kilometer or deeper, separated by periods when the vertical temperature gradients are much stronger. The occurrence of weaker/stronger vertical gradients is a sign of stronger/weaker vertical mixing, so the agreement between the model and observations indicates that the processes controlling vertical mixing are reasonably represented in the model. These include the direct effect of wind-driven mixing as well as the influence of buoyancy fluxes that can sometimes result in heavier water temporarily overlying lighter water—an unstable situation that is quickly corrected by a process known as convective mixing.

The success of the numerical model in simulating the variations in mixed layer conditions tells us that the model currents and mixing processes are represented sufficiently well to provide reasonable estimates of the variations in upper-ocean temperature and salinity. These same effects (particularly vertical mixing) are critical in determining biological productivity. To investigate the influence of variations in these physical processes on biological productivity, we have embedded a standard four-compartment (phytoplankton, zooplankton, detritus, and dissolved inorganic nitrogen) biological model into the physical model described above. The biological model simulates processes that remove nutrients from the water and turn them into phytoplankton biomass (primary production), as well as those that complete the cycle by releasing the nutrients locked in the marine biomass back into the water. These processes are dependent on ambient light, nutrients, and temperature, all factors that are readily available when the biological model is coupled with the circulation model. Such a coupled physical-biological model is a very powerful tool to connect atmospheric forcing and ocean dynamics to marine productivity.

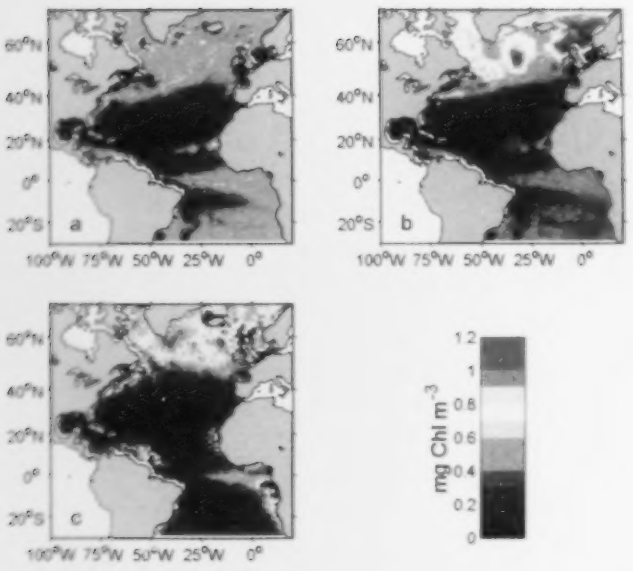


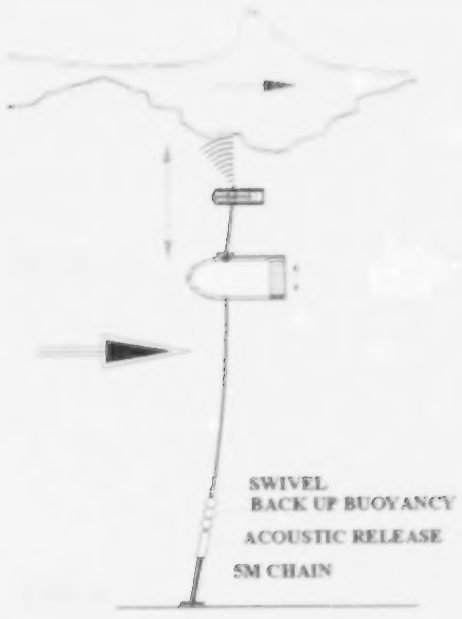
Figure 2. August horizontal distribution of the surface chlorophyll "a" concentration (mg Chl m-3) in the North Atlantic: a) the model solution obtained with constant biological parameters; b) the model solution obtained with spatially variable biological parameters; and c) SeaWiFS (http://seawifs.gsfc.nasa.gov/SEAWIFS.html) data for the month of August averaged over 1997-2003.

As a starting point for our investigation of biological processes, we consider the ability of the coupled physical-biological model to reproduce a typical seasonal cycle in productivity under typical forcing conditions. That is, we run the model with the annual cycle of forcing consistent with the average of the annual cycles over the past few decades. We then check to see if the annual cycle in productivity produced by the model is consistent with the corresponding observed annual cycle. Figures 2a and 2b show the phytoplankton biomass simulated for the month of August in the North Atlantic for two different versions of the biological model. The simulation shown in Figure 2a uses generally accepted biological parameters that are constant in space and time. The simulation shown in Figure 2b uses spatially varying biological parameters based on previous applications of the biological model to different regions of the North Atlantic. Both simulations can be compared to the biomass estimated from satellite observations for the period 1997 - 2003 (Figure 2c). The simulation with varying parameters is a much more accurate representation of the observed biomass field. This reflects the fact that ecological communities are not the same everywhere and that they respond differently to the same environmental influences (light, nutrients, and temperature). Additional experiments have shown that reasonable changes in the physical model have less influence on the agreement between the model simulation and the observed biological fields than these changes to the biological model.

The above discussion deals with the model's ability to simulate the seasonal cycle in productivity over the North Atlantic. While we have found that the prescription of biological parameters strongly influences the results, we know that variations in physical processes such as vertical mixing will also influence biological productivity. As illustrated by Figure 1, these physical processes vary substantially over time and we expect that there will be corresponding variations

Novel Technology for Profiling near the Surface under Arctic Ice: The Icycler

- George Fowler



in biological productivity.

Fortunately, satellite observations of ocean colour have been used to estimate ocean biological productivity over the past 24 years (although the record was interrupted between 1986 and 1997 because there was no ocean colour instrument in orbit over that period). One finding of this work is that in addition to strong annual variations, there are also strong inter-annual variations in productivity. These include variations in the magnitude, timing, and in location of maximum productivity from year to year. These results are at least qualitatively consistent with the observed variations in physical conditions. The next steps will be to determine if our coupled model can simulate these inter-annual variations and to determine the role of changes in physical conditions in determining this variability. This work is in progress. If past variability can be reproduced, then future variability might be anticipated from the results of climate change models.

Novel Technology for Profiling near the Surface under Arctic Ice: The Icycler

- George Fowler

Recent concern about potential melting of the permanent cover on the Arctic Ocean (Arctic Ice Cap) has led to increased oceanographic survey operations in the Canadian Arctic Archipelago. Of major interest are the identification and quantification of the fresh water produced by the melting process, since this water eventually flows into the North Atlantic where it becomes a component of general ocean circulation. Monitoring this fresh water is a challenge because it occurs immediately beneath the ice, where it is impossible to maintain an instrument because of ice ridge keels that sweep down-channel.

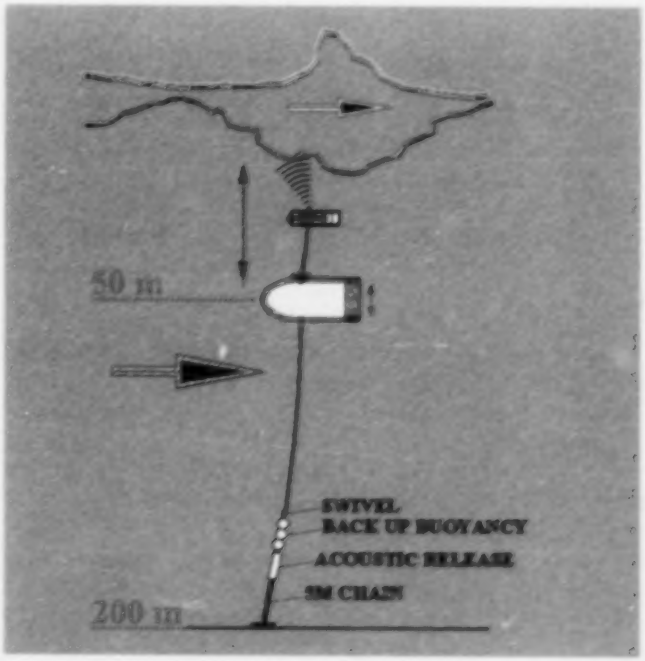
To solve the problem of making long term measurements where none have been made before, DFO Ocean Physics staff developed the Icycler. The Icycler is an instrument support platform that is capable of moving an instrument upwards into this danger zone from a safe distance beneath the ice and then recovering it out of harm's way. This is accomplished using a subsurface installation that consists of two separate buoyant components. A larger main float carries a winch system that controls the depth of a much smaller instrument-equipped float by paying out or hauling in a cable connecting the two floats. The system is programmed to operate automatically for a year, making daily profiles from a depth of 50 m to a point immediately beneath the ice.

To make the measurements, the instrument float houses a Datasonics echo sounder, a Seabird 19+ CTD (Conductivity, Temperature, Depth) sensor with pump, and a Wetlabs fluorometer along with control electronics in a streamlined enclosure. The echo sounder monitors the distance to the underside of the ice during each profile and controls the depth to which profiles are made. The pump draws water from the outside through the sensors during the vertical ascent stage of the profile. The instruments and hoses are protected from biological growth with an anti-foulant device located at the entry point.

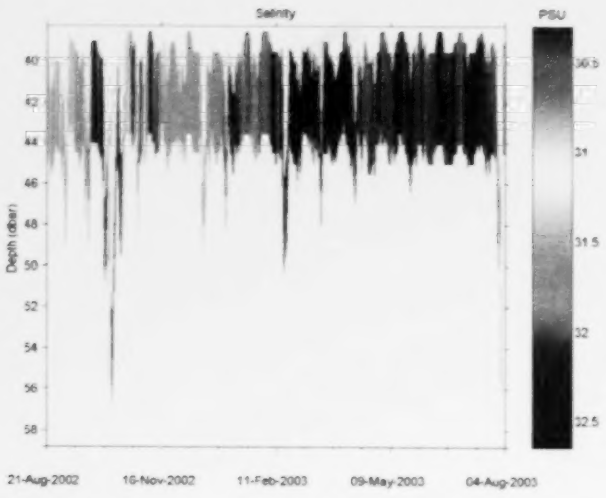
Data are relayed from the instrument float to the main float via the electro-mechanical instrument float cable where they are stored inside the winch drum. This instrument float winch drum also serves as the main pressure case for the system enclosing the drive motor, main batteries, and system electronics. Cable spooling is accomplished by moving the whole winch assembly back and forth. The winch is designed to be neutrally buoyant so as to preserve the trim of the subsurface float.

The greatest challenge to the Icycler's effectiveness is posed by its energy demands. Because of water currents, the buoyancy required to minimize the "dip" of the mooring is substantial; consequently, the energy required to cycle the instrument float from its safe deep position to the near surface and back down, every day for a year, is considerable. To make year-long deployments feasible, the winch system embodies a mechanism that permits the conservation of the energy expended by the vertical movement of the instrument float much like an underwater elevator. However, instead of using the weight and counterweight balance of the elevator, it employs two buoyancies in dynamic equilibrium displaced by two winch drums geared to rotate in opposite directions: one for the instrument float line and one for the subsurface float mooring line.

A buoyant element moving vertically through the water



Typical High Arctic Icycler mooring design

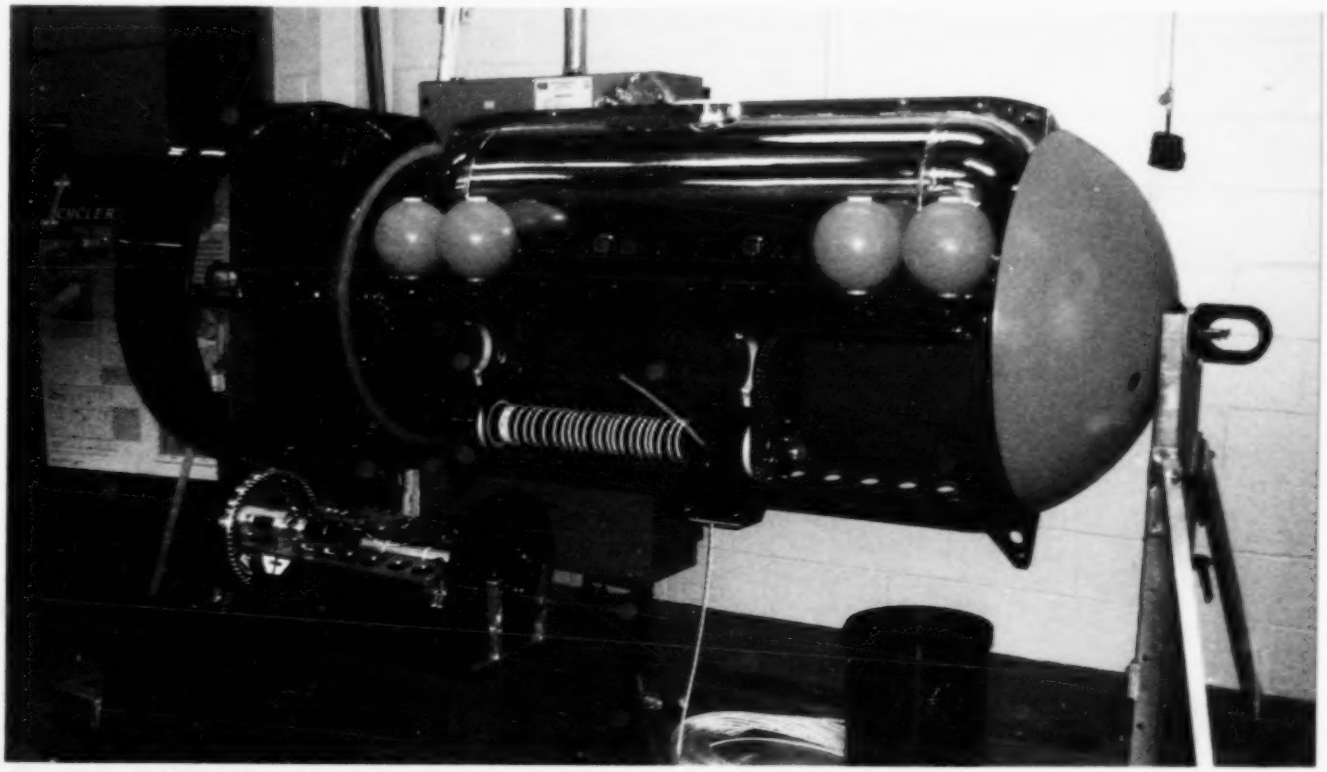


Salinity data from a one-year deployment under the ice in Lancaster Sound

increases its potential energy as it goes deeper, and decreases it as it ascends. Further, the energy is equal to the product of buoyant force and distance traveled. Thus, a small buoyant element travelling a large distance could expend the same energy as a large buoyant element travelling a small distance. The Icycler uses this principle in a double-drum winch to move the small instrument float to the surface and back while moving the much larger main float a much smaller distance in the opposite direction. Taking water velocity into consideration, the net vertical motion of the instrument float can be reduced to 50 meters. While there are efficiency losses, they are no larger than a normal winch system, and the energy conserved considerably reduces power requirements, making daily monitoring possible.

The prototype system was tested several times in local waters to work out bugs and has been twice successfully deployed under the ice in the Gulf of St. Lawrence for two-month periods. It was moored in Lancaster Sound in the summer of 2002 and recovered a year later. While it successfully completed 350 cycles, a programming error limited the height of each profile. After correcting the program, a new battery pack was installed and the system was re-deployed in the same location for another year.

We continue to make improvements to the Icycler design. After its recent deployment we became aware of shortcomings in the design of the prototype. Of paramount concern were several sources of energy loss which, while not great enough to limit the system's overall objective of a one-year deployment, were significant enough to warrant change. An improved Icycler II has been designed and is nearing the end of a test program, where lab and field trials indicate that the new unit is dramatically more efficient than the original. This system embodies a new type of underwater motor, called "SeaMotor", which has no penetrating drive shaft and hence, no seawater seal. This innovation and a novel power transmission system have contributed significantly to a reduced power budget. The unit is currently deployed under the ice in the Northumberland Strait. To date, the program has been concerned exclusively with equipment development. However, in the summer of 2004 the Icycler will be deployed as part of the Arctic Through Flow Mooring Program in Lancaster Sound where scientific data will be collected to help scientists understand Arctic circulation patterns and to validate computer models employed in climate studies.



The Icycler Main Float showing the "SeaMotor" drive package in the foreground

BIO Science in Partnership

State of the Ecosystem Report for the Eastern Scotian Shelf

– Kenneth Frank, Ken Drinkwater, Glen Harrison, Brian Petrie, and Phil Yeats (Ocean Sciences Division, DFO); Alida Bundy (Marine Fish Division, DFO); Heather Breeze, Scott Coffen-Smout, Kirsten Querbach (Oceans and Environment Branch, DFO); Robert O'Boyle (Associate Director of Science, DFO); and Jae Choi (Department of Biology, Queen's University, Kingston, Ontario)

The *State of the Ecosystem* report is a compilation and analyses of data relevant to the evaluation of the Eastern Scotian Shelf ecosystem. In the past, no one document has provided a comprehensive, integrated assessment of the current status of a large ocean area or ecosystem under Canadian jurisdiction. Our analyses focused on all available data associated with three categories of variables: biotic, abiotic, and human. Biotic variables generally include information on the abundance, distribution, and composition of finfish and invertebrates, phyto- and zooplankton, and marine mammals. Abiotic variables include oceanic and atmospheric data that provide insights into ocean climate conditions. Human variables include fishery landings and revenue, contaminants, and activities associated with oil and gas development. The current evaluation used over 60 data series, most of which extend back to at least 1970. By examining temporal trends in the data an assessment was made of the current status of the ecosystem relative to its previous state. The report, now available from http://www.dfo-mpo.gc.ca/csas/Csas/English/Status/Status_Reports2003_e.htm, represents a step toward consolidation and synthesis of the ever-growing body of data resulting from various monitoring programs.

GEOGRAPHIC AREA

The Eastern Scotian Shelf, comprising NAFO Div. 4VW, is a large geographic area (~108,000 km^2) supporting a wide range of ocean uses such as fisheries, oil and gas exploration and development, and shipping. It is currently the focus for the development of an integrated management plan referred to as ESSIM (Eastern Scotian Shelf Integrated Management) with the intent to harmonize the conduct of the various ocean use activities within the area. The Eastern Scotian Shelf consists of a series of outer shallow banks and inner basins separated by gullies and channels. The mean surface circulation is dominated by southwestward flow, much of which originates from the Gulf of St. Lawrence with anticyclonic circulation tending to occur over the banks and cyclonic circulation around the basins. The northeastern region of the shelf is the southern-most limit of winter sea ice in the Atlantic Ocean. The area is unique for having a year-round closure for directed fishing of groundfish established in 1987, associated with Emerald and Western banks. In addition, DFO has declared the area associated with The Gully as a pilot marine protected area. As in several other areas in the northwest Atlantic, the once dominant cod fishery collapsed in the early 1990s.

INTEGRATION OF DATA

An overall picture of the changes that have taken place on the Eastern Scotian Shelf since 1970 was addressed by adopting an approach similar to the traffic light framework used in stock assessments. Sixty-four metrics were used in the evaluation with 50 representing primary indices and 14 indicative of second order indices, that is higher level processes such as community composition, ratios of variables, and growth, among others. The indices were made directly comparable to one another by expression as anomalies (deviation from long-term mean) in standard deviation units. Colors were used to display the magnitude of the anomalies ranging from strongly negative (red) to strongly positive (green). The color scheme was not chosen to convey judgment on the direction of change (i.e. good or bad). The metrics were ordered using Principal Components Analysis to identify any coherence in the manner in which the indicators changed over the study period. Thus, the sequence of the indicators reflects the degree of similarity in their temporal dynamics.

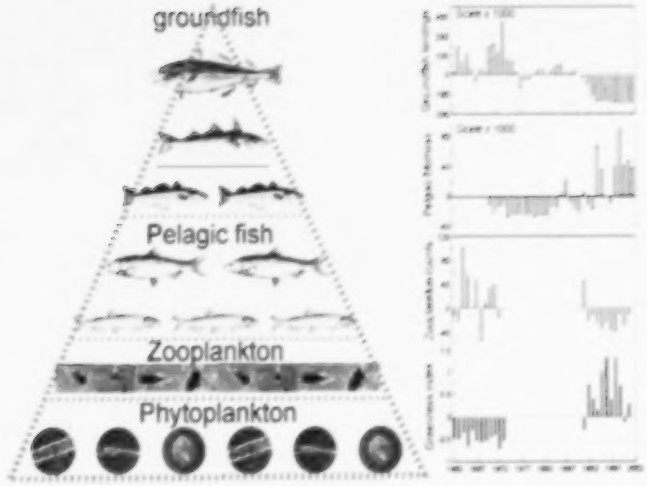
SYSTEMIC CHANGES

Seal abundance, pelagic fish abundance, landed value of shellfish, fish species richness, and phytoplankton (greenness) were among the several metrics that changed in a coherent manner relative to

Time series of annual anomalies of variables used in the evaluation of the Eastern Scotian Shelf ecosystem. Green blocks indicate above normal conditions, red below normal conditions, and white normal conditions or missing data.

those further down the list during the 1970s to the early 1980s. These metrics all exhibited negative anomalies. Subsequently, these metrics shifted to all positive in the 1990s to the present. Conversely, anomalies of bottom temperatures at Misaine Bank, commercial exploitation levels, groundfish landings and biomass, growth rates of cod, haddock and pollock, average individual fish weight and copepod counts, were all positive during the 1970s to the early 1980s. In addition, warm bottom temperatures, a weakly-stratified summer water column, and a deeper mixed-layer typified the abiotic conditions at this time. During the 1990s, almost all of these positive anomalies became negative at a time when bottom temperature declined, mixed layer depth lessened, and the water column became more intensely stratified. Overall, what is visually striking is the change in state from one extreme to the other for almost all the metrics over the study period, with the transition occurring between the years 1985 to 1990. The changes observed were systemic and coherent.

The causes of these patterns remain as yet unexplained. However a few key hypotheses are being investigated: 1) "Top-down" or predator control of food webs is one possible explanation for the reciprocal changes in abundance among alternating trophic levels.



A simplified food chain of who eats whom on the Eastern Scotian Shelf beginning at the top with groundfish, then with small pelagic fish, zooplankton, and finally phytoplankton; the corresponding data for each level to the right of the schematic suggests the existence of a "trophic cascade".

When the indicators of groundfish abundance were high during the 1970s/mid-1980s, pelagic abundance was low, zooplankton abundance was high, and chlorophyll was low. Throughout the 1990s, when the indicators of groundfish abundance were low, a reversal of this pattern was evident. 2) Physical changes associated with increased stratification could favour the proliferation of a pelagic-based food web and limit the flux of nutrients to the benthos. 3) Cooling and increased advection were associated with colonization by sub-Arctic species, increases in abundance of snow crab and shrimp, and declining groundfish productivity. Coupled with high exploitation pressure on groundfish, dominant species such as cod and haddock may have been made more susceptible to these physical changes. These hypotheses are not mutually exclusive and elements of each one may be contributing to the observed patterns.

FOCUS: THE FISH COMMUNITY

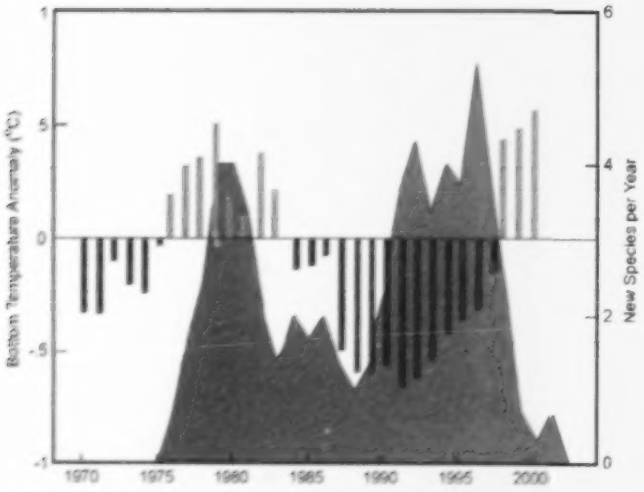
Profound changes in community composition and body size of groundfish have occurred during the past thirty years on the Eastern Scotian Shelf. The historical composition of the top five species based on abundance included: redfish, American plaice, silver hake, haddock, and cod. This dominance structure has changed dramatically during the past decade and pelagic species

such as sand lance, capelin, and herring are now dominant. Only silver hake and haddock have remained near the top since the early 1980s, while cod, redfish, white hake, and thorny skate have decreased. In addition, ten to fifty fold increases in the abundance of daubed shanny, turbot, snake blenny, and sea poachet were evident in the most recent period relative to 1981-1997. It is notable that the increasing species are all small-bodied, with the exception of turbot. In addition, temperature conditions appear to influence the occurrence of new species in the area, particularly when conditions remain persistently above or below normal. Several species of sub-Arctic origin were first recorded during the anomalous cooling period that began in the mid-1980s, including shorthorn sculpin, sea tadpole, Newfoundland eelpout, two horn sculpin, little grubby, and checker eelpout. Overall, thirty species new to the area have been captured since 1991, with the vast majority less than 35 cm in length. Conversely, during the warm water conditions that began in the late 1970s several warm temperate/sub-tropical species were captured including beardfish, barracudina, batfish, greeneye, common wolfeel, deep-water flounder, and snipe eel.

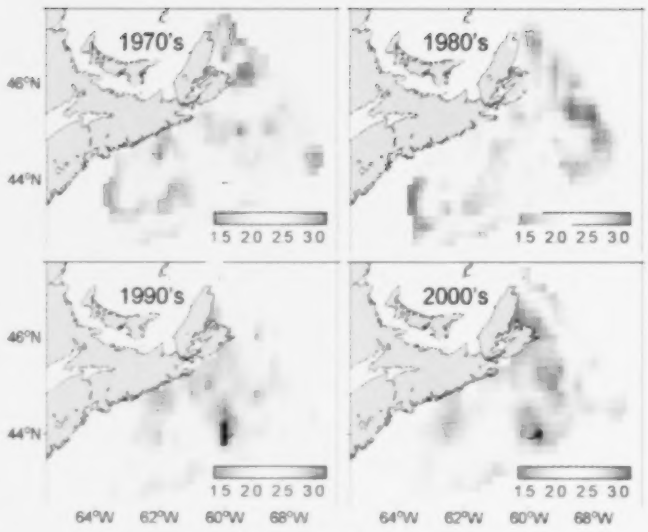
The temporal changes in fish species composition and abundance suggest that decreases in length and weight, averaged across all groundfish species, would be evident. The pattern of reduced weight (in kilograms) was most evident during the 1990s with the largest reduction in the northeastern areas.

Changes in length mirror these patterns. Declining average weight not only reflects increased abundance of small bodied species but also contracted size distribution of large-bodied species. For example, adult cod, haddock, and pollock at age 5 are now much smaller, on average, compared to individuals from the 1970s and 1980s. Reductions in size at age have also occurred in silver hake. The trend of reduced size has occurred despite current low population levels suggesting that a fundamental, population dynamic process (compensatory growth) is not working among these species.

As a direct consequence of the geometric scaling of numerous



The occurrence of fish species new to the Eastern Scotian Shelf depends, in part, on temperature conditions (shown as a histogram). When warm bottom waters prevail an influx of sub-tropical species occurs (first peak in the diagram). Conversely, cold water conditions were associated with a peak (second spike) of sub-arctic species.



Mean weight of fish on the Eastern Scotian Shelf for the 1970s, 1980s, 1990s, and 2000-02: the scale ranges from 2.5 kg (dark green) to 0.063 kg (dark red).

physiological, population-dynamic, and life-history characteristics with organism size (allometry), there exist numerous potential implications of these changes in average body size associated with the formerly large-bodied species of the Eastern Scotian Shelf. The most notable are: shorter generation times, increased natural mortality, increased population variability, and decreased bioenergetic efficiencies. For example, direct estimation of natural mortality for cod and haddock was made possible by closure of the directed fishery and revealed levels 2-5 times higher than commonly assumed. Such changes do not necessarily translate to an unhealthy ecosystem but do indicate that it is functioning in a vastly different manner than in the past.

Currently, we are estimating system-level "structural" (biomass) and "functional" (metabolic rates, estimated from size-frequency distributions) changes of the fish component of the Scotian Shelf ecosystem. Visualizations of these metrics in a spatial-temporal context and the relative discordance between structure and function will provide a direct estimate of system-level instability of the fish community. Another avenue of research that is being investigated is the use of size-spectral information in the context of "Self-Organized-Criticality" (Bak et al. 1989) to provide another means of evaluating system-level instability. Finally, comparative analyses are planned between other systems that have not shown strong ecosystemic changes, for example, locations where collapses of major fish stocks have not occurred. This will advance knowledge on the causes of these large-scale changes in both ecological structure and function and the potential to identify early warning signs of such hysteresis.

REFERENCES

Bak, P., K. Chen, and M. Creutz. 1989. "Self-organized Criticality in the 'Game of Life." *Nature* 342:780-782.

DFO 2003. State of the Eastern Scotian Shelf Ecosystem. DFO Ecosystem Status Report 2003/004.

A River Worth Saving: The Installation of a Bottom Draw Siphon on the St. Francis Harbour River

- Bob MacDonald of the Mulgrave Lakes Enhancement Association, with Darren Hiltz, Habitat Management Division, DFO Maritimes Region

Nova Scotia is blessed with rivers that once were a magnet to both domestic and foreign anglers. Today acidic precipitation, land and water degradation, and other environmental factors have put these rivers in peril. The last decade has seen a groundswell of grassroots activity towards rejuvenating our productive waterways. Through education and the application of sound habitat restoration principles, our once prosperous freshwater sport fishery is being revived. Fisheries and Oceans Canada (DFO) continues to play a key role with many partners in supporting the work of community groups in fish habitat restoration. The recent involvement of the Habitat Management Division (HMD) in the restoration of the St. Francis Harbour River shows what co-operation and joint action can accomplish.

To lure anchor industries to the Strait of Canso area, in 1959 the Province of Nova Scotia dammed the outflow from the three Goose Harbour lakes, creating an 865-hectare water impoundment that would later supply the Stora Enso paper mill with fresh water. Unfortunately, no provision for maintenance flows or fish passage was incorporated into the reservoir. As a result, three kilometers of streambed immediately downstream of the dam was dewatered, making it nonproductive as a spawning and rearing habitat for trout and salmon. The low flows also limited the overall carrying capacity of juveniles on the entire river. Additionally, summer high water temperatures and excessive winter ice resulted in disproportionate egg mortality from ice scouring and freezing conditions. Although there was significant spillage over the dam in early spring and late fall, this was essentially lost in small tributaries that eventually made their way back to the St. Francis Harbour River but never benefited the river to its maximum.

In 1999, a concerned citizens' group took on the task of returning the river to a healthy trout and salmon stream. After meeting with HMD staff, corrective measures were formulated. These measures focused on: migration, pre-spawning, spawning, incubation, rearing, feeding, and over-wintering.

Following consultations with DFO, the Province, and StoraEnso, in the spring of 2000 the Mulgrave and Area Lakes Enhancement Association (MALEA) successfully raised funds to build passage over the concrete portion of the dam. This would facilitate access into the head-pond by migratory fish and deliver impounded fish to favorable spawning sites downstream. The group commissioned an engineering firm to design the fish ladder and hired a local contractor to build and install it. The fish ladder was operational in the fall of 2000.

Log drives in the early 1900s had left areas of the river devoid of pools of significant depth. The second rehabilitative step took place with help from HMD staff through 2001-02. After much debate it was agreed to construct functional habitat improvement structures in the headwater areas impacted by the outflow from the new fish ladder. HMD staff, aided by the *Adopt-A-Stream* project co-ordinator, laid out a template for their construction and five students were hired to carry out the placement of the in-stream structures. Over time, these structures re-establish the natural meandering features of a healthy river system. The "homes" would provide refuge to adult trout and salmon that entered during spate rains in summer and early fall. The deep-water sanctuaries would also over-winter both trout and salmon kelts after spawning.

It became evident that most important to the creation of a healthier river system was increased water flow through the channel. To accomplish this would require co-operation among several groups. Trout Unlimited Canada and MALEA spearheaded meetings in January, 2003 with StoraEnso, the operators of the headwater reservoir; HMD staff from both the Maritimes and Gulf Regions; and the Nova Scotia Department of Agriculture and Fisheries. The need for a continual discharge of water from the head- pond was discussed. Because no provision for continuous release had been incorporated in the dam, the concept was somewhat foreign to StoraEnso officials. However, they agreed to evaluate their water needs and to discuss the overall project.

In early July, StoraEnso agreed to the installation of a bottom draw siphon over the dam. The water flow was to be five cubic feet/second in normal times, reduced to three cubic feet/second under severe drought conditions. The company supplied all stainless steel pipe and materials needed for the siphon, a contribution worth over $25,000. It was agreed that MALEA would construct the siphon and install rocking on both sides of the berm.

The headwater reservoir which is the source of cold water for the siphon - photo by Bob MacDonald

Small Craft Harbours, Sydney office, contributed $7500, towards the project as part of habitat compensation requirements associated with Small Craft Harbours projects. MALEA successfully canvassed both the local and international private sector. Exxon Mobil donated $3000; Maritimes & Northeast Pipelines gave $2000; Strait Engineering designed the layout valued at $1000; East Coast Hydraulics paid for flexible pipe which cost $750; and Maritime Marietta, the local quarry, provided rock worth $1000.

The siphon was constructed in September, 2003. After sounding and surveying the lake bottom, the eight-inch pipe was laid 260 feet into the reservoir. This allowed access in summer to cool water from a depth of 21 feet. On the riverside, an eight-inch gate valve was installed to control discharge during droughts. After two weeks of fabricating and welding, the pipe work was sunk, then secured and bolted to the section going over the dam and down to the dry riverbed. To start water flow, the valve was closed, and the fill line was incorporated into the overall design and filled with water. Once the fill line was closed, the valve was opened and the siphon process became operational.

Initial samples showed water pulled off the lake bottom to be a constant 12° Centigrade, with dissolved oxygen content at 108% of the before-siphon measurement. Calculations showed total daily output of 2,880,000 gallons and the creation of at least three kilometers of new headwater, with a further three-four kilometers positively impacted by this new coldwater maintenance flow.

The benefits of this maintenance flow will be evident in spring 2004, when more favorable conditions will be present for over-wintering juvenile trout and salmon in those headwater sites. As well, egg deposition from fall spawning should reduce mortality from ice buildup.

The St. Francis Harbour River after siphon installation, fall 2003 – photo by Jack Ronald

The co-operation of DFO HMD and Small Craft Harbours staff was paramount in the success of this project. Nova Scotia Department of Agriculture and Fisheries played a critical role in collecting pre-siphon data so a comparison could be made to measure the benefit of the bottom draw. Last but not least, the private sector gave generously. All partners believed that the St. Francis Harbour River was *a river worth saving*.

Validation of Sea-Ice Properties in Satellite Imagery

- Ingrid Peterson (DFO), Simon Prinsenberg (DFO), Scott Holladay (Geosensors Inc.), and Louis Lalumiere (Sensors by Design Ltd.)

For many months of the year, sea ice is a major navigational hazard off the Canadian East Coast and in the Canadian Arctic. Information on ice extent, concentration, thickness and floe size is available to mariners on ice charts produced daily by the Canadian Ice Service. The ice chart information is used also by scientific researchers for detecting and assessing the impact of climate change, and for initializing and validating numerical ice-ocean models. The ice charts are based mainly on the interpretation of satellite synthetic aperture radar (SAR) imagery, but also incorporate information from other satellite imagery, airborne radar imagery, and helicopter and shipboard observations. Since the early 1990s, field surveys have been conducted by DFO in partnership with Canadian companies and other government departments, to collect measurements of sea-ice properties using helicopter-borne sensors. This information is used both for incorporation into ice charts, and for validating algorithms used to infer sea ice properties in SAR imagery.

During the field surveys, sea ice thickness and surface ice roughness are measured with a helicopter-borne electromagnetic (HEM) system, or "Ice Probe", consisting of a cigar-shaped sensor package or "bird" towed 15 m above the ice surface (Figure. 1). An electromagnetic sensor provides the distance from the bird to the bottom of the ice, while a laser altimeter also contained in the bird provides the distance to the surface of the snow or ice. Together the sensors give the snow-plus-ice thickness. The laser altimeter data are also used to provide ice surface roughness. Video mosaics are collected with a video-laser system, which captures image frames in real-time from a downward-looking video camera in a pod mounted on the helicopter skids (Figure 2). The video mosaics are used to monitor ice conditions such as ridging, ice concentration, and floe size along the flight path. In the late 1990s, a HEM system that is fix-mounted on the nose of a helicopter was developed for the Canadian Coast Guard, since it is less cumbersome for the pilot to operate, particularly from icebreakers (Figure 3). Termed the "Ice Pic", it can be used either to obtain spot samples of level ice thickness by soft-landing on the ice, or to collect short ice-thickness profiles by flying slowly at low altitude over the ice. The footprint size, which is dependent on the altitude of the sensor above the seawater surface, is 6-12 m for the Ice Pic, compared to 40-75 m for the Ice Probe. Several studies have been done to validate snow-plus-ice thickness measurements from both the Ice Probe and Ice Pic by comparing them with ice and snow thicknesses measured in holes drilled through the ice.

Figure 1. The Ice Probe, a towed helicopter-borne electromagnetic system for measuring sea ice thickness, is shown above sea ice in the Gulf of St. Lawrence.

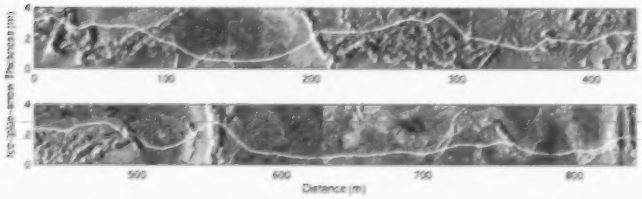


Figure 2. Video mosaic of heavily ridged sea ice off the north shore of Prince Edward Island has ice-thickness measurements from the Ice Probe superimposed in yellow. The mosaic is about 50 m wide and 850 m long and ice thickness measurements are along the centre of the image with the ice thickness scale on the vertical axis.

Satellite SAR imagery, which has been available since the early 1990s, is unaffected by cloud cover and has a spatial resolution of 100 m or better. From the imagery, information on ice concentration and floe sizes is extracted, and different stages of development, or ice types, are identified, each having a particular ice thickness range. A radar signature is a set of image characteristics used to identify a particular ice type in radar imagery, such as image tone and texture, floe size and shape, the appearance of fractures, and the occurrence of rafting and ridging. Ice types can often be identified by their radar signatures because the radar return from ice is affected by surface roughness, ice salinity and bubbles in the ice, and these properties differ among ice types. Radar signatures are dependent on the frequency and polarization of the radar, the incidence angle, and the image resolution. The radar signatures also vary with season since the radar return is affected by snow wetness, melt ponds, and large

Figure 3. The Ice Pic is a fix-mounted helicopter-borne electromagnetic system for measuring sea ice thickness, shown on board icebreaker.

grain-sizes in any overlying snow.

Since the early 1990s, field studies in the Gulf of St. Lawrence, over the Labrador Shelf, and in the Arctic Archipelago have been conducted to validate sea-ice signatures in SAR imagery from the ERS-1 and RADARSAT-1 satellites, and from fixed-wing aircraft (Canada Centre for Remote Sensing Convair 580). An example from March 2001 in the Gulf of St. Lawrence shows ice thickness data along a long flight path to and from the Magdalen Islands, and along short lines near the north shore of Prince Edward Island (Figure 4). Ice thickness measurements were highest within about 10km of the north shore of PEI because of compaction of the ice by onshore winds, causing extensive ridging. There were also many large floes about 2 m thick in this inshore region. In the RADARSAT SAR image, the floes and ridged areas appear brighter than the surrounding ice. Farther offshore, the level ice is generally 20-40 cm thick and there is little ridging. Patches of thin rafted ice

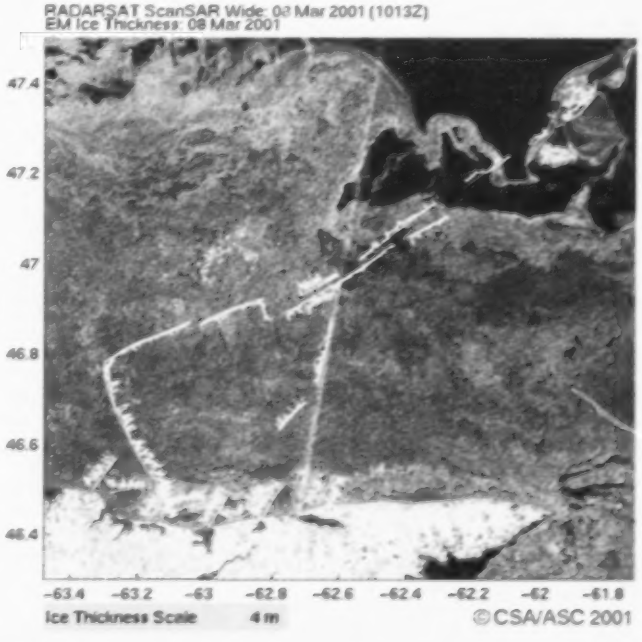


Figure 4. Ice-thickness measurements from the Ice Probe superimposed on a RADARSAT SAR image (130km by 130 km) of sea ice north of Prince Edward Island

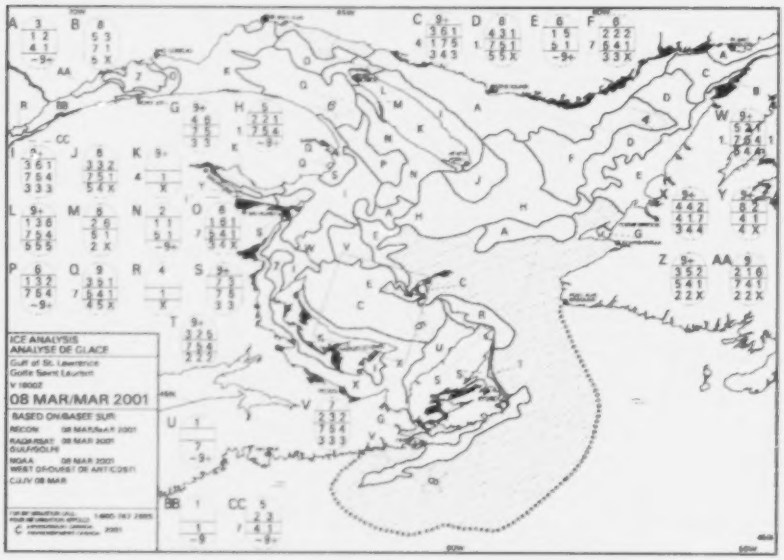


Figure 5. Ice chart for March 8, 2001 for the Gulf of St. Lawrence was produced by the Canadian Ice Service. The red square shows the approximate area covered by the RADARSAT SAR image.

about 20 cm thick are observed both near the coast and in the offshore region, and appear dark in the imagery due to the smooth surface. In the ice chart for the day of the field survey (Figure 5), area "C" corresponds to the offshore region, where the ice code indicates that all the ice is less than 120 cm thick (30% is 70-120 cm, 60% is 30-70 cm and 10% is 15-30 cm). Area "X" corresponds to the inshore region where thicker ice was observed with the Ice Probe, and where the ice chart shows 40% of the ice to be greater than 120 cm thick.

The helicopter-borne sensors for measuring sea-ice thickness have been used for many years in scientific studies such as the validation of radar sea-ice signatures. However, they are now being used increasingly as operational tools in the production of ice charts, which provide ice information for a variety of users including mariners and climate researchers. In particular, the helicopter-borne sensors provide absolute ice thickness measurements of the thicker level ice that cannot be obtained from satellite SAR imagery.

Coastal Remote Sensing Applications in Canada's Western Arctic

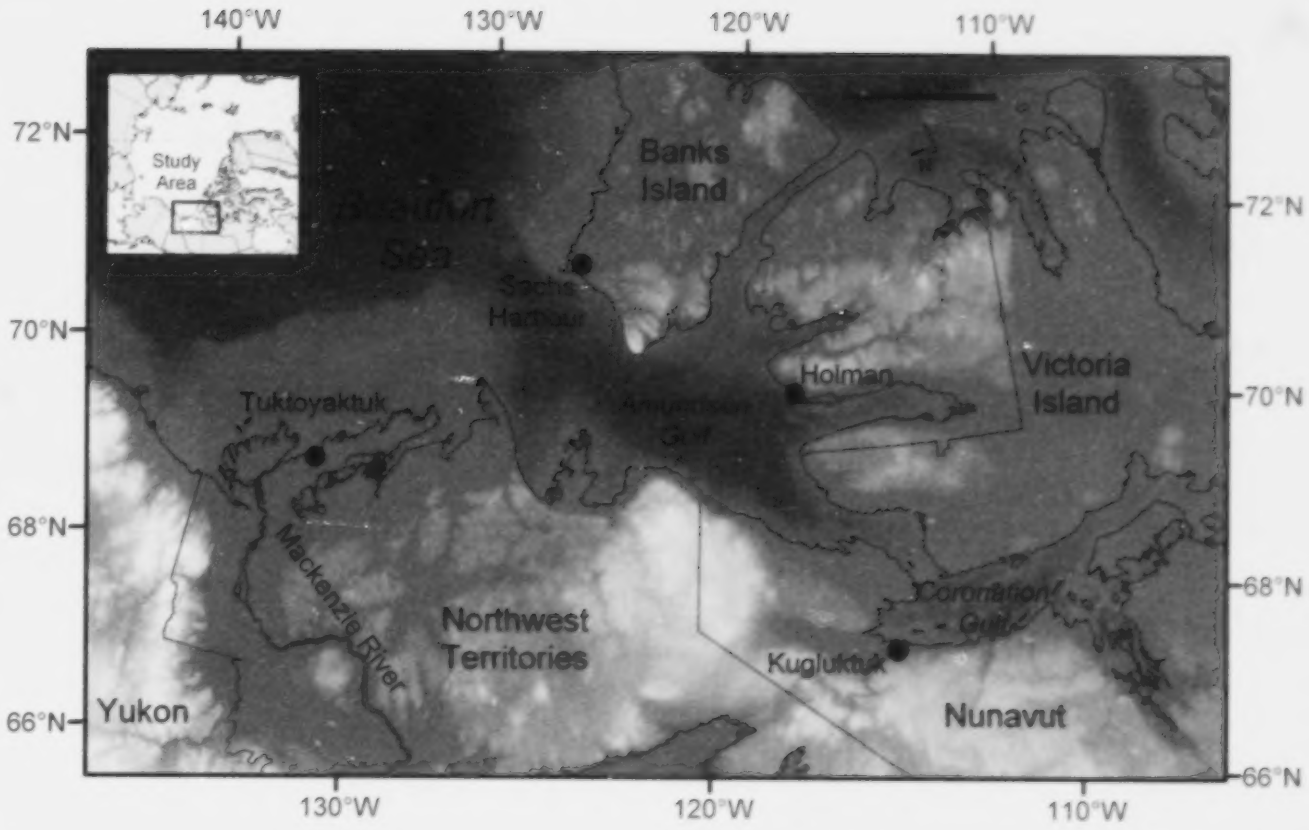
- Gavin Manson, Steve Solomon, and Donald Forbes (Geological Survey of Canada, NRCan), Joost van der Sanden (Canada Centre for Remote Sensing, NRCan), Costas Armenakis (Centre for Topographic Information, NRCan)

At almost 250,000 kilometers, Canada's coastline is the longest in the world. Much of it is remote and inaccurately mapped. Recent oil and gas exploration in the Western Canadian Arctic and the potential impacts of a warming climate and longer ice-free seasons have re-emphasized the need to map and monitor Arctic coastal morphology and physical changes. In such remote areas as the Western Canadian Arctic, traditional ground-based methods for collecting these data are difficult, costly, and time-consuming. Recent advances in both optical and radar sensor technology, and improved accessibility to imagery have greatly increased the potential for use of remote sensing for coastal geomorphic research.

NRCan scientists are developing methods for the use of remote sensing in coastal process research and change detection. The investigations are funded in part by the Canadian Space Agency and involve collaboration with other government departments and private sector firms. The broad strategy has been to test different sensors and techniques in accessible locations with good groundtruth data (such as the north shore of Prince Edward Island) and to migrate those proven to be successful and applicable to the Western Canadian Arctic. The most successful space-borne technologies have been found to be high resolution multi-spectral imagery for mapping and change detection, and non-polarimetric and polarimetric radar for nearshore sea ice process studies. In addition, airborne technologies displaying considerable promise in a variety of applications include Light Detection And Ranging (LiDAR).

In the past, coastal remote sensing for geomorphic research has been hindered by the low spatial resolution of satellite sensors. Even the LandSat-7's advanced resolution in the panchromatic band is not adequate for mapping fine-scale beach morphology and detecting rates of change for process research on coasts that migrate less than a few metres per year. Two new satellites, QuickBird and IKONOS, carry sensors with 4 m to 0.6 m resolution that are making precise coastal measurements possible from space. Comparable resolution is available in the microwave portion of the spectrum with fine mode imagery from the Canadian RADARSAT with 6.3 m resolution.

QuickBird and IKONOS imagery from 2002 and 2003 are being used in Sachs Harbour as well as other Western Arctic communities to map coastal change in conjunction with groundtruth measurements made with high-precision Global Positioning Systems. Initial results suggest that it is now possible to measure from space changes in waterline position caused by individual storms. These satellites may also be used to measure change in the nearshore, either by interpretation of bar positions in a time series of images or by mapping bathymetry based on attenuations of different wavelengths in water.



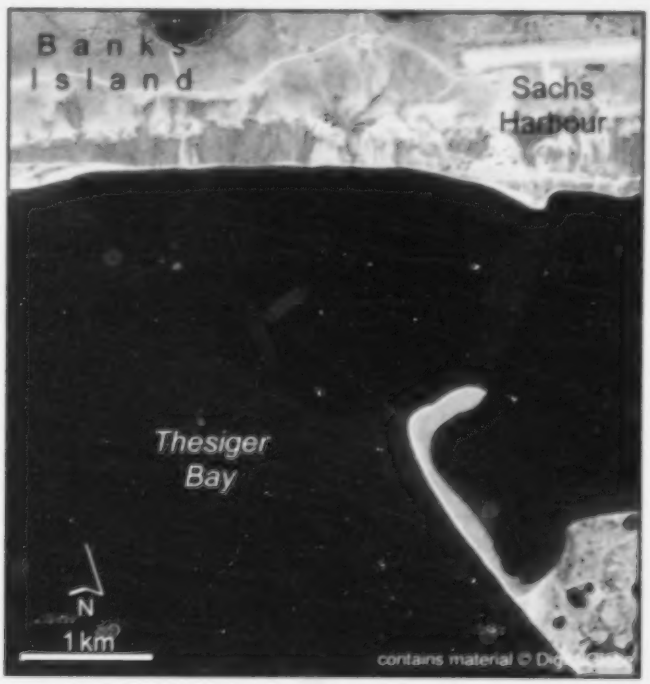
Location map showing communities where imagery has been collected

Both techniques have been demonstrated on the north shore of Prince Edward Island, and the clear waters at Sachs Harbour suggest that they may be successfully applied there too.

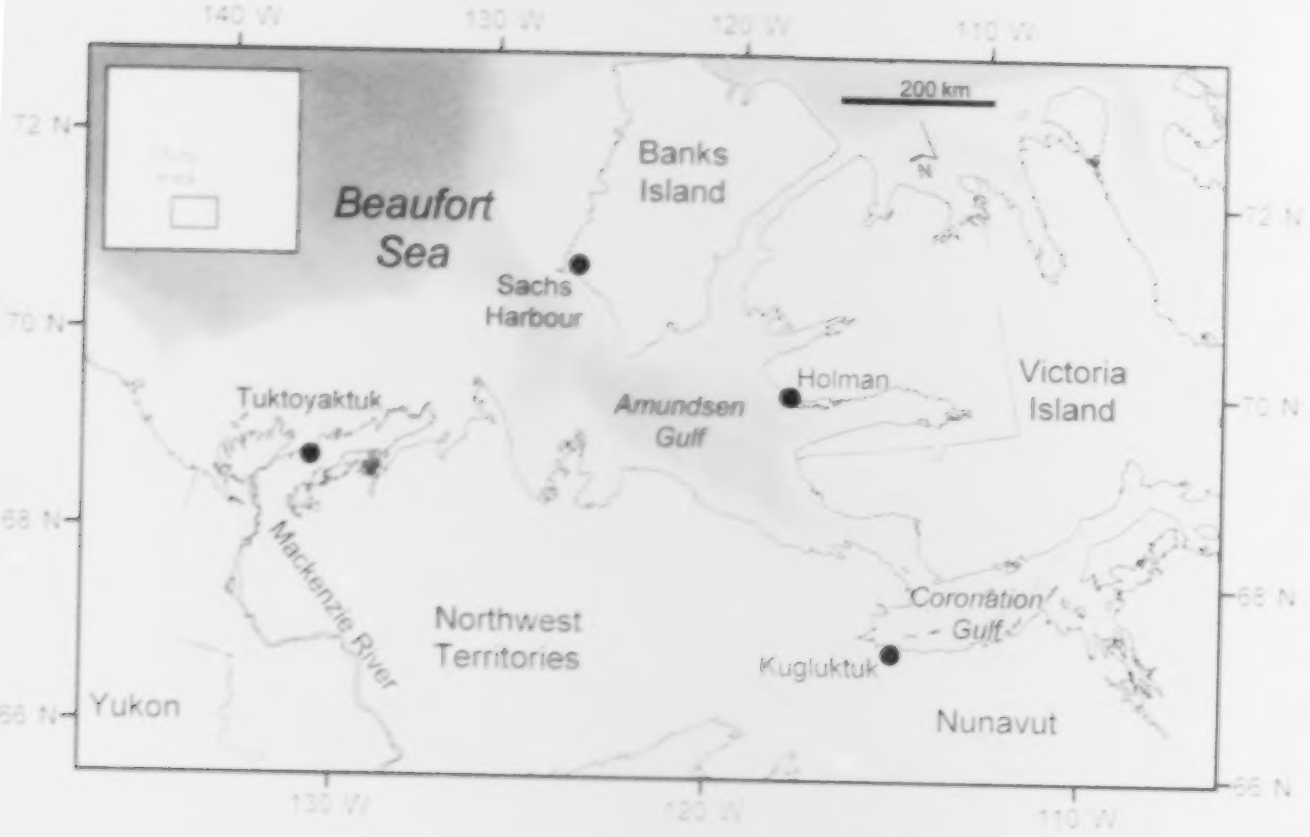
Synthetic Aperture Radar (SAR) remote sensing capacity has been developed in Canada because of its utility for ice mapping and, being an active sensor technology, because it is not limited to daylight or cloud-free conditions. The coastal applications of such satellite sensors as ERS1 and 2, RADARSAT, and ENVISAT ASAR include mapping of storm surge flooding and nearshore sea ice. An image captured during an intense storm in the vicinity of Tuktoyaktuk in 2000 shows the extent of storm surge flooding in a part of the Mackenzie Delta.

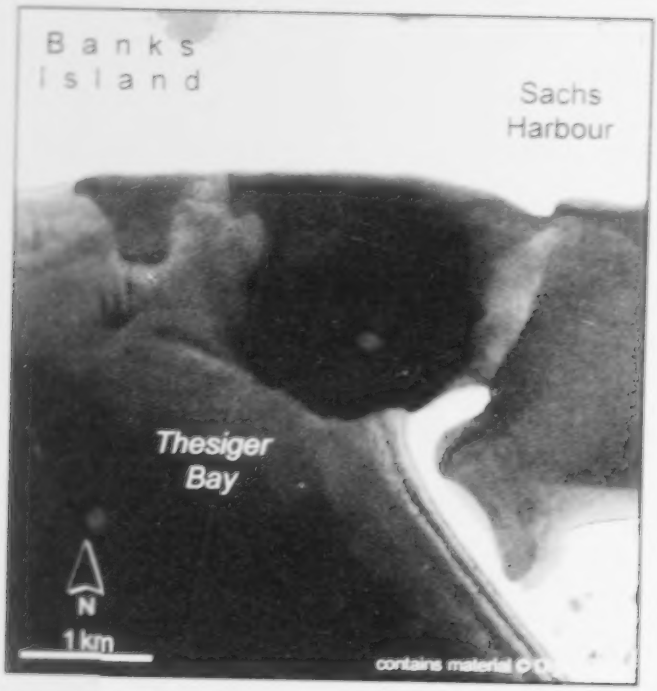
Nearshore sea ice is important for reducing the impacts of winter storms, and as a platform for transportation, oil and gas exploration, and traditional subsistence activities. Despite this, little is known about the seasonal evolution and structure of landfast ice. Government, industry, and academic partners are building on the successful use of airborne polarimetric synthetic aperture radar in the southern Gulf of St. Lawrence. A current project is focused on using spaceborne polarimetric SAR to map landfast and coastal lake ice to develop new ice mapping products useful to northern residents and the oil and gas and transportation industries. Polarimetric SAR is analogous to multispectral optical imagery, delivering more information through different channels. Fully polarimetric capability at high resolution is a key feature of Canada's RADARSAT-2, expected to be launched in late 2005.

Pioneered in Canada, LiDAR, has not been used extensively in this country for coastal applications. It can deliver digital elevation models (DEM) with vertical and horizontal resolutions of less than 0.3 m and 1 m respectively. The resulting DEMs can be used for morphologic and process interpretation and measurements, coastal flood



QuickBird imagery of Sachs Harbour, July, 2003


140 W
130 W
120 W
110 W
72 N
70 N
68 N
66 N
200 km
N
Banks
Island
Beaufort
Sea
Sachs
Harbour
Tuktoyaktuk
Amundsen
Gulf
Holman
Victoria
Island
Mackenzie River
Northwest
Territories
Coronation
Gulf
Kugluktuk
Yukon
Nunavut


Banks
Island
Sachs
Harbour
Thesiger
Bay
N
1 km

RADARSAT standard mode image of pack ice in the Beaufort Sea (1), landfast ice in Kugmallit Bay (2), and the ice road connecting Tuktoyaktuk with Inuvik (3)

mapping, and change detection, and as a shaded relief base map on which other imagery types can be overlaid.[1] LiDAR measurements are very similar to those acquired by swath mapping systems (e.g. multibeam and sweep sonars) for nearshore bathymetry, and the combination can be used to develop seamless onshore-to-offshore DEMs. Indeed, the bathymetric LiDAR system known as SHOALS is capable of measuring water depths to approximately 50 m, and is being used to repetitively map the US coast. Only small portions of the Canadian coastal zone have been mapped using either the terrestrial or bathymetric LiDAR systems, though the former is being considered in a new initiative to improve mapping in the Mackenzie Delta.

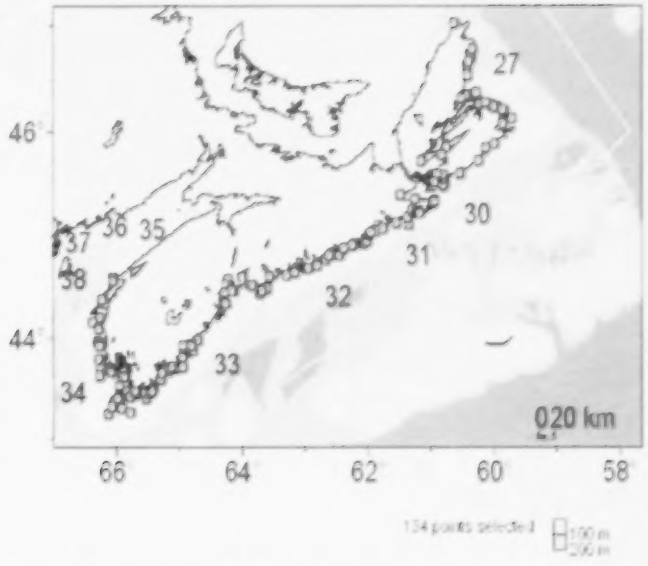
Some of the impacts of changing climate, such as sea level rise, which could increase rates of coastal change and the frequency and severity of coastal flooding, are expected to be felt the most in Canada's Western Arctic. With more development and potential for increased shipping through an ice-free Northwest Passage, a strong requirement exists for updated, accurate maps of Canada's coasts, suitable for baseline coastal process and change detection research applicable to climate change adaptation and coastal zone management. The spaceborne and airborne sensors being considered in the described research all display potential applications in meeting this requirement.

Canada and USA Fishermen Collaborate on Lobster Recruitment Research

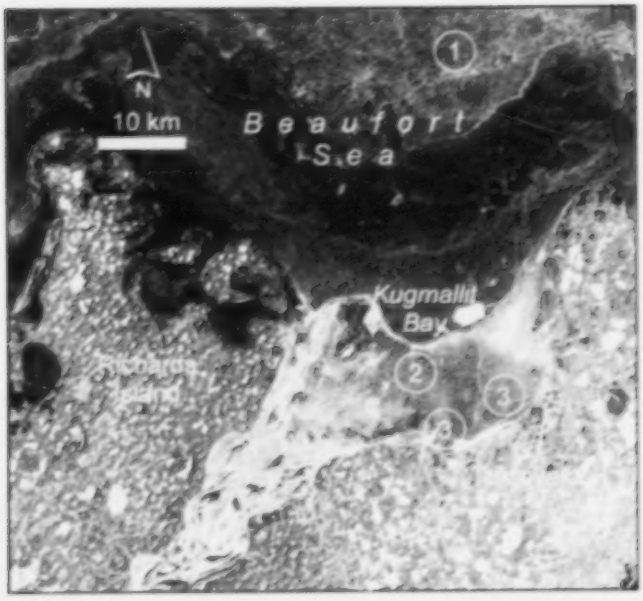
- Patty King (Fishermen and Scientists Research Society [FSRS]), Patrice Farrey (Gulf of Maine Lobster Foundation and the Maine Lobstermen's Association), Carl MacDonald (FSRS), and Shannon Scott-Tibbetts (FSRS)

The Fishermen and Scientists Research Society (FSRS), is an active non-profit partnership of fishermen and scientists working on research to promote the sustainability of our fishery resources. Several BIO scientists are member of the FSRS, and through a joint agreement between DFO and the FSRS, the office is located at BIO. In the spring of 1999, the Society launched a short-term lobster recruitment index project designed to study the number and size of juvenile lobsters that will be recruited into the fishery in the upcoming seasons. During the regular commercial season, fishermen use two to five scientific lobster traps to gather information about undersize lobsters in their area. Volunteer fishermen maintain a logbook on the number, sex, and size of lobsters from their science traps. These fishermen also indicate if lobsters are berried, tagged, and/or v-notched. To control spatial variation, each year the standard traps are fished in the same locations. One hundred fifty nine fishermen from Lobster Fishing areas (LFAs) 27 to 34 are currently involved in the project.

Collecting information about juvenile lobster over a number of years allows the development of a recruitment index. Over time, trends develop in the data allowing prediction of lobster recruitment in upcoming seasons. Lobster fisheries in Atlantic Canada rely heav-



Location of FSRS recruitment project traps during the 2002 spring fishery; the numbered areas outlined on the map are Lobster Fishing Areas (LFAs).



RADARSAT standard mode image of pack ice in the Beaufort Sea (1), landfast ice in Kugmallit Bay (2), and the ice road connecting Tuktoyaktuk with Inuvik (3)

mapping, and change detection, and as a shaded relief base map on which other imagery types can be overlaid. LiDAR measurements are very similar to those acquired by swath mapping systems (e.g. multibeam and sweep sonars) for nearshore bathymetry, and the combination can be used to develop seamless onshore-to-offshore DEMs. Indeed, the bathymetric LiDAR system known as SHOALS is capable of measuring water depths to approximately 30 m, and is being used to repetitively map the US coast. Only small portions of the Canadian coastal zone have been mapped using either the terrestrial or bathymetric LiDAR systems, though the former is being considered in a new initiative to improve mapping in the Mackenzie Delta.

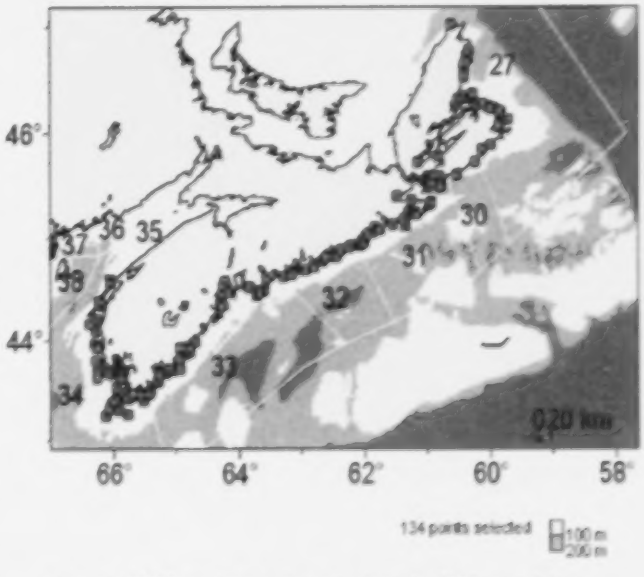
Some of the impacts of changing climate, such as sea level rise, which could increase rates of coastal change and the frequency and severity of coastal flooding, are expected to be felt the most in Canada's Western Arctic. With more development and potential for increased shipping through an ice-free Northwest Passage, a strong requirement exists for updated, accurate maps of Canada's coasts, suitable for baseline coastal process and change detection research applicable to climate change adaptation and coastal zone management. The spaceborne and airborne sensors being considered in the described research all display potential applications in meeting this requirement.

Canada and USA Fishermen Collaborate on Lobster Recruitment Research

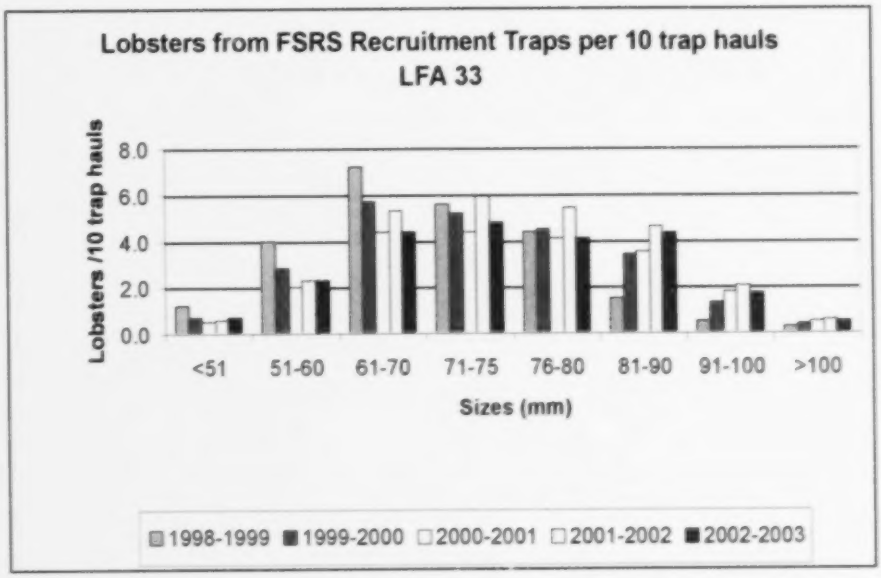
- Patty King (Fishermen and Scientists Research Society [FSRS]), Patrice Farrey (Gulf of Maine Lobster Foundation and the Maine Lobstermen's Association), Carl MacDonald (FSRS), and Shannon Scott-Tibbetts (FSRS)

The Fishermen and Scientists Research Society (FSRS), is an active non-profit partnership of fishermen and scientists working on research to promote the sustainability of our fishery resources. Several BIO scientists are member of the FSRS, and through a joint agreement between DFO and the FSRS, the office is located at BIO. In the spring of 1999, the Society launched a short-term lobster recruitment index project designed to study the number and size of juvenile lobsters that will be recruited into the fishery in the upcoming seasons. During the regular commercial season, fishermen use two to five scientific lobster traps to gather information about undersize lobsters in their area. Volunteer fishermen maintain a logbook on the number, sex, and size of lobsters from their science traps. These fishermen also indicate if lobsters are berried, tagged, and/or v-notched. To control spatial variation, each year the standard traps are fished in the same locations. One hundred fifty nine fishermen from Lobster Fishing areas (LFAs) 27 to 34 are currently involved in the project.

Collecting information about juvenile lobster over a number of years allows the development of a recruitment index. Over time, trends develop in the data allowing prediction of lobster recruitment in upcoming seasons. Lobster fisheries in Atlantic Canada rely heav-



Location of FSRS recruitment project traps during the 2002 spring fishery: the numbered areas outlined on the map are Lobster Fishing Areas (LFAs)



Location of FSRS recruitment project traps during the 2002 spring fishery. Trend in lobster catches for LFA 33 by 10 trap hauls: shown are the FSRS Lobster recruitment traps results from fall 1998 to spring 2003. This project is continuing into 2004 with a change in the measuring gauge values and in collaboration with the GOMLF.

Participants in the FSRS Lobster Recruitment Study show off one of FSRS lobster traps – photo by Jamie Lent

ily on newly recruited lobster which highlights the importance of predicting recruitment in projecting increases or declines for the commercial lobster fishery.

A similar project, the Ventless Trap Survey, was introduced in 2002 in the New England lobster fishery. In 2002, the Gulf of Maine Lobster Foundation (GOMLF), a non-profit association dedicated to research with the lobster industry, took over the project because of: 1) a high level of interest from the fishing community, 2) gaps in the commercial catch data that needed to be filled, and 3) a need for more data to assist in stock assessment.

It was around that time that Patty King, FSRS General Manager and Patrice Farrey, Executive Director of GOMLF and the Maine Lobstermen's Association, discussed possible collaboration on research. They noted the similarities and differences between their projects and how the groups could collaborate. Through these discussions it was concluded that it would be valuable to have a workshop to look at standardizing the projects and developing a collaborative action plan.

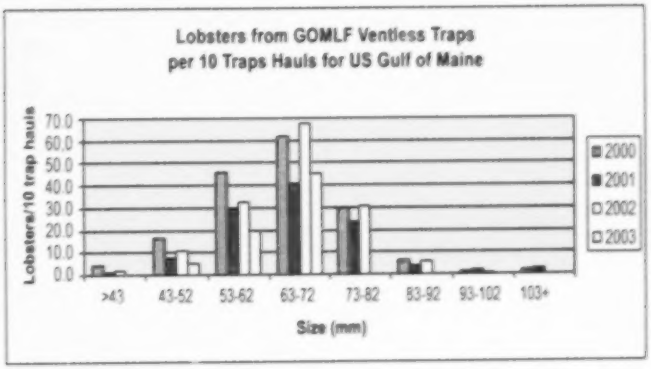
The Joint Fishermen and Scientists Research Society - Maine Lobstermen's Association Collaborative Lobster Recruitment Research Workshop was held on February 19 and 20, 2003 in Halifax, Nova Scotia. The objectives of the workshop were to: review experiences with trap-based, short-term recruitment monitoring projects within the Atlantic Canada/Gulf of Maine region; work towards a consensus on the best approaches for this research (including trap configuration and experimental design); secure a future regionally-coordinated development path for these trap-based approaches in which lobster fishermen play a crucial role; and promote partnerships among regions of Atlantic Canada, and between Atlantic Canada and the Gulf of Maine region.

One advantage of the joint workshop was to solidify the working relationship between the Canadian and USA groups. It also expanded the geographic scope of lobster recruitment research so that it is possible to get a more complete picture of what is happening in the lobster fishery along the east coast from Cape Breton, Nova Scotia to New England.

Collaboration has enabled the FSRS and GOMLF to standardize the core components of the project such as trap and measuring gauge design, data collection, and data management. It allows them to share data and knowledge. Since the fishermen in both areas share the lobster resource, it seems logical to share the science. By working jointly, everyone can have more complete information for making decisions on resource conservation and management.

At the workshop it was agreed to continue this cross-border exchange by holding an annual event. Plans are underway for a workshop in Maine in March 2004 as part of the Maine Fishermen's Forum. It is hoped also that this collaboration on lobster recruitment research will lead to collaboration on other projects.

Location of Gulf of Maine Lobster Foundation participants, 2003



Trend of lobster catches for the GOMLF ventless trap survey from the year 2000 to 2003: the values on the axis are different from the FSRS Lobster recruitment trap study since different measuring gauges were used.

Assessing Potential Impacts of Seismic Activity on Northern Bottlenose Whales in the Proposed Gully Marine Protected Area

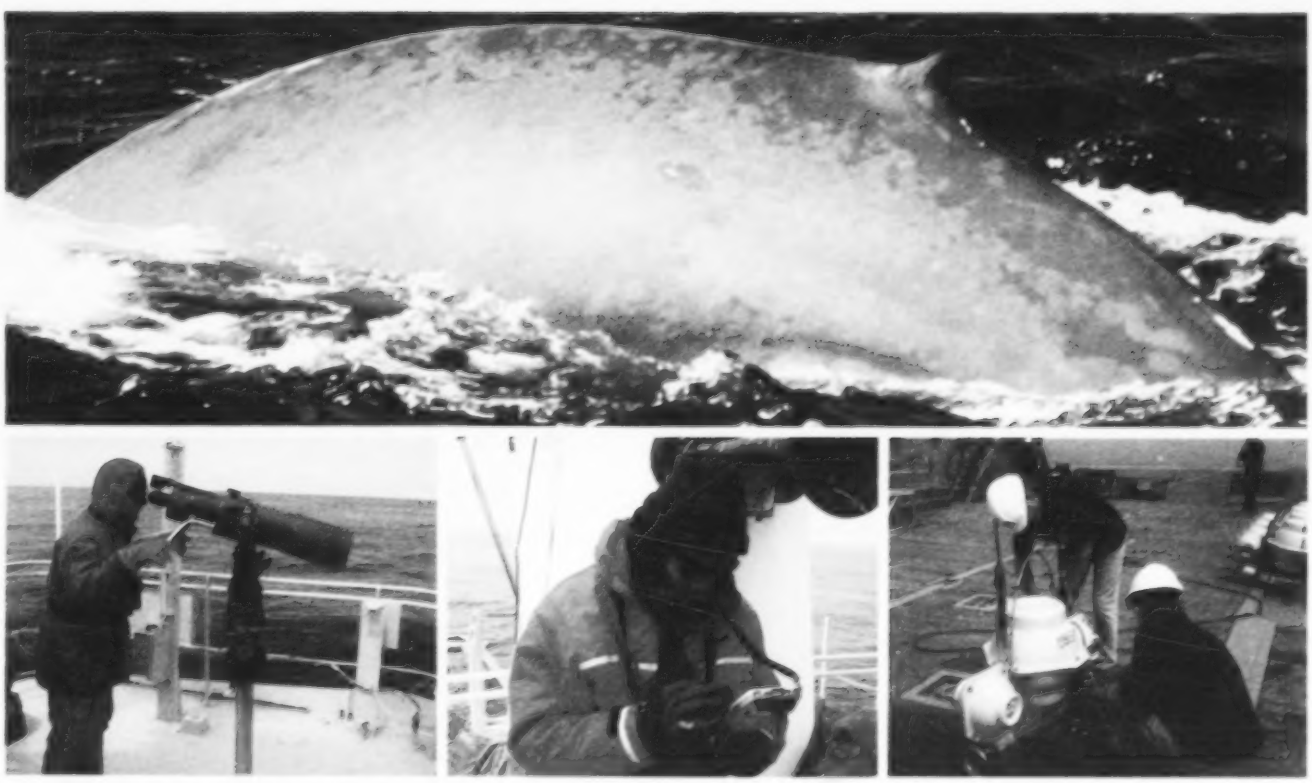
- *Kenneth Lee and Rosalie Allen Jarvis*

Whales use sound for navigation, communication, and echo-location of prey. With the expansion of offshore oil and gas activities on the east coast of Canada, there are concerns that underwater noise generated by exploratory activities may impact the resident populations of marine mammals in The Gully and adjacent underwater canyons. Of particular note, northern bottlenose whales, which are known to congregate within these canyons, are considered endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

In 2003, new licenses were issued by the Canada-Nova Scotia Offshore Petroleum Board (CNSOPB), which resulted in the submission of proposals for seismic surveys in deep-water areas near The Gully. Considering that the magnitude and frequency of seismic surveys off Canada's coastline will likely increase in the future, the Centre for Offshore Oil and Gas Environmental Research (COOGER) coordinated a research program in conjunction with seismic operations by Marathon Canada Limited and EnCana Resources Corporation, which was given approval by the CNSOPB. The purpose of this study was to validate propagation models for sounds generated by seismic air source arrays and to evaluate their potential influence on the abundance and distribution of marine mammals.

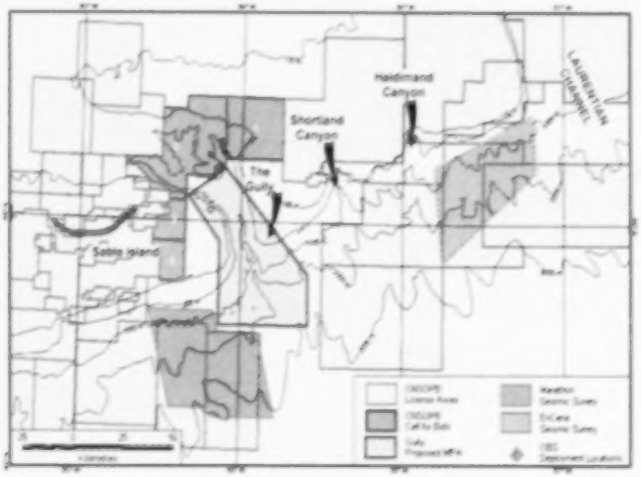
Based in part on advice provided by DFO, the CNSOPB imposed a mitigation plan for the protection of whales. It included monitoring of the near-field acoustic levels (within 5 km of the sound source), gradual increases in sound levels to allow marine mammals to escape from the area, and deployment on the seismic vessel of observers who would call a halt to operations if whales entered the area. Despite these protective measures, due to a lack of conclusive scientific evidence on their effectiveness, concern remained for northern bottlenose whales and other marine mammals (for example, blue, fin, and sperm whales, seals, and dolphins) in The Gully and two adjacent canyons in the region.

To obtain information on marine mammal species presence and



Top: A rare blue whale is sighted from the M.V. Strait Signet. Left: A marine mammal observer uses "Big Eyes" binoculars to identify animals. Middle: Steven Benjamins, a marine mammal observer from Newfoundland, enters information related to a whale sighting into a data logger aboard the M.V. Strait Signet. Right: An ocean bottom seismometer, used to record sound levels underwater, is recovered from a sampling station in The Gully

Kenneth Lee (Executive Director, Centre for Offshore Oil and Gas Environmental Research) and Jean-François Gosselin (Research Scientist, Quebec Region and Chief Scientist aboard the M.V. Strait Signet) examine a chart of The Gully.



This map indicates that the areas in which Marathon Canada Ltd. and EnCana Resources Corp. undertook seismic activity were outside The Gully, a proposed Marine Protected Area (MPA). Research data were also gathered in Shortland and Haldimand Canyons, adjacent to The Gully.

distribution, observers on the oceanographic research vessel, M.V. *Strait Signet*, collected data along a transect line more than 400 km in length prior to and during the seismic testing period (April 2003 and July 2003 respectively). In addition to species identification, data obtained included observations of marine mammal behaviour (such as group size, surface intervals, swim speed, swim direction, and feeding). Six extremely sensitive underwater microphones called ocean bottom seismometers were used. These instruments were modified by Natural Resources Canada (NRCan) to capture the range of frequencies from air source arrays to whale vocalization. The ocean bottom seismometers and hydrophones deployed from the M.V. *Strait Signet* provided direct measurement of acoustic pulses from the seismic operations, which allows for the validation of sound propagation models. The information gathered can potentially identify whale species and track any alterations in their distribution and density.

The results of this study will provide a base to support future research by the proponents, DFO, and academics to assess the potential impact of seismic activities. This project has provided a comprehensive database of species, locations, and abundance for marine mammals, including northern bottlenose whales and other COSEWIC-listed species, in and near the Sable Gully area. Project deliverables, including improved sound propagation models, will be used by industry to improve risk assessment predictions in future Environmental Assessment reports, which are required as part of the regulatory approvals process for new projects. These data will be employed in the development of scientifically-defensible, precautionary sound exposure thresholds, which will be used to establish acoustic Marine Environmental Quality (MEQ) targets (acceptable sound levels and safe operating distances) in the ocean environment to ensure protection of our marine environment.

This project includes team members from four DFO regions (Maritimes, Quebec, Newfoundland, and Pacific), the University of Quebec at Rimouski, and Natural Resources Canada. It provides a unique opportunity to improve our scientific knowledge base required for risk assessment and our technological ability to monitor operations in the field. The results will provide key information on distribution and abundance of marine mammals and identify potential mitigation procedures useful for protecting the marine environment in future proposals for seismic exploration. The final report for this research program and recommendations for further data analysis will be prepared by fall 2004.

Jack Lawson, a DFO research scientist from Newfoundland, videotapes a northern bottlenose whale from aboard the M.V. Strait Signet.

This important research has been supported by Anadarko Petroleum, Atlantic Canada Opportunities Agency, British Petroleum, DFO's Species at Risk Funding Program, EnCana Resources, Environmental Sciences Research Fund, Marathon Canada, Natural Resources Canada, Nova Scotia Department of Energy, and Petroleum Research Atlantic Canada.

Onshore Geoscience in Nova Scotia: The Targeted Geoscience Initiative in Southwestern Cape Breton Island

- Peter S. Giles

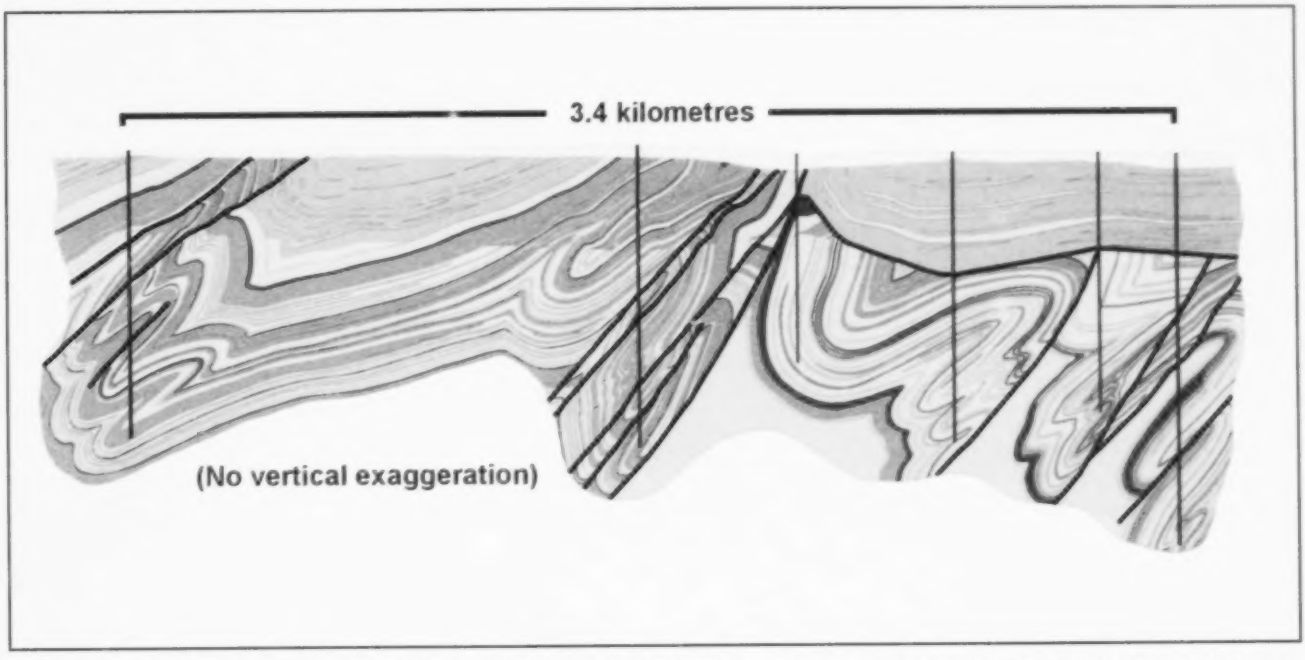
The bringing ashore of natural gas from the Scotian Shelf has created renewed awareness of opportunities for industrial development in the Strait of Canso region. Mineral resources, traditionally important to all of Nova Scotia, can contribute to economic enhancements linked to this exciting new development in the energy sector. In order to realize benefits from mineral development, both the federal and provincial governments recognized the fundamental importance of scientific understanding of these resources as a guide to mineral exploration. To this end, the Nova Scotia Department of Natural Resources and Natural Resources Canada collaborated on a three-year program of geological mapping and resource assessment in southwestern Cape Breton Island, as part of the national Targeted Geoscience Initiative (TGI). The aim of the TGI project was to provide new geological information essential to maintain or expand present resource utilization, and to determine the potential for new opportunities in the mineral resource sector.

Completed in the spring of 2003, the co-operative effort addressed a principal area extending from the Strait of Canso easterly to St. Peter's and northerly to Whycocomagh. Compilation of regional airborne geophysical data for the preparation of summary maps covered even broader regions of southern Cape Breton Island. Throughout the project, communications were maintained with local development agencies at annual meetings where results were presented. The mineral exploration community was invited each year to participate in guided field trips. Here geological relationships were demonstrated and opportunities were provided for first-hand perusal of project results.

Success in mineral exploration and development depends on many factors relating directly to geoscience understanding. Ultimately, one must know where to look, what to look for, the geological factors that may improve (or diminish) chances for success, the variety of mineral resources present, their quantity, and their quality. The identification of a potential mineral resource is, in most cases, a very preliminary first step. In the TGI project area, a long history of mineral production and deep drilling have proven the presence of gypsum and rock salt in large quantities. Crushed bedrock aggregate is an important contributor to the provincial mineral economy and a major quarry operation on tidewater at Auld's Cove is familiar to most Nova Scotians.

Rocks of Carboniferous age underlie much of the TGI project

TGI field trip participants on the outcrop on the shores of the Strait of Canso north of Auld's Cove



Geological cross-section through the MacIntyre Lake salt deposit is based on detailed study of cores from six deep wells. Both halite (rock salt) and potash salts occur in this deposit. Current interest in the deposit is for the development of large caverns suitable for the storage of hydrocarbons. Pink colours represent layers of rock salt. Heavy lines in black are faults.

area and host the known gypsum and salt deposits. These sedimentary rocks occupy low-lying portions of the project area and are often covered by a blanket of glacial material, sometimes an impediment to bedrock investigations but itself an important source of mineral commodities. Upland areas such as Sporting Mountain, North Mountain, and the Creignish Hills, are underlain by much older rocks which have potential to provide an entirely different spectrum of mineral resources. Geological mapping at 1:50,000 scale successfully delineated these rock sequences and their glacial cover at surface. The maps provide an important guide to the location of potential resources. In combination with geophysical data which were concurrently compiled for the map area, these maps also reveal major fault structures which may have served to channel mineralizing fluids, thus providing focus for exploration of metallic minerals along their trace. In order to better characterize the nature and thickness of glacial deposits, shallow seismic reflection surveys were undertaken in selected areas. Part of this effort was to test for the presence of hidden deposits of Cretaceous silica sands or kaolinite (clay) similar to those documented as thin cover sequences in other Carboniferous basins in Nova Scotia. These Cretaceous deposits are known in sporadic occurrences on Cape Breton Island and are currently utilized elsewhere in the province. Within the glacial cover sequence, TGI mapping revealed, for the first time, thick deposits of glacial clay suitable for a variety of uses. These clays are currently used by local potters and broader industrial uses are possible. Within the older rocks of the upland areas adjacent to the Carboniferous basins, TGI mapping delineated marble deposits suitable for industrial use. Recently, one richly coloured marble deposit has begun to produce dimension stone and terrazzo as a commercial venture.

As part of the project effort, all known industrial and metallic mineral showings were visited to permit update of current information available through provincial databases. Subsurface data provided by mineral exploration drilling and water-well records were updated and expanded where necessary so that this valuable source of geological information would also be available to explorationists and the larger geological community. In several instances, project geologists studied subsurface core material in detail in order to better understand the geological relationships hidden as deeply as 1000 meters beneath the present surface. A geological cross section based on deep drilling at MacIntyre Lake provides an excellent example of this activity, and illustrates the level of geological complexity which confronts the unwary explorationist who might wish to utilize the salt resources in that area. All project results, including technical and scientific reports and databases, as well as geological and geophysical maps of the project area, are available through our partner, the Nova Scotia Department of Natural Resources: (www.gov.ns.ca/natr).

The TGI project in southwestern Cape Breton Island provided valuable training for young earth scientists from several Nova Scotia universities, employed during the summer as field assistants. Of particular importance was the opportunity to gain experience in geological mapping, a skill which is difficult to learn without training in the field. In addition, graduate thesis work at Acadia University involving geological mapping and stratigraphic studies was supported in the first two years of the project, leading to successful completion of a Masters of Science degree in Geology.

Perhaps the clearest demonstration of overall project success is the recognition of the TGI project approach as a national model for cooperative and collaborative geoscience. The southwestern Cape Breton Island TGI project was supplanted in 2003 by a new effort in central Nova Scotia in which a similar model for cooperative geoscience involves geoscientific staff of the Nova Scotia Department of Natural Resources and Natural Resources Canada, and researchers from several Canadian universities.

Offshore Oil and Gas Environmental Effects Monitoring Workshop: Approaches and Technologies

- *Shelley Armsworthy, Peter Cranford, Kenneth Lee, and Rosalie Allen Jarvis*

The discharge of wastes into the ocean during offshore oil and gas operations is an important environmental issue in Canada. Numerous studies, conducted over the past decade by scientists at the Bedford Institute of Oceanography (BIO) and the Northwest Atlantic Fisheries Centre (NWAFC), have played an integral role in the development of scientific advice used to update regulatory guidelines for the treatment and ocean discharge of these wastes (summarized in Cranford et al. 2001, *Scientific Considerations and Research Relevant to the Review of the 1996 Offshore Waste Treatment Guidelines*). While these research programs have addressed many issues, gaps remain in knowledge regarding the environmental fate and effects of operational wastes. To ensure protection of the marine environment and its resources, Environmental Effects Monitoring (EEM) programs are conducted during development and production at offshore petroleum platforms. EEM programs have been carried out at all offshore production platforms in eastern Canadian waters since the development of the first oil production site off Nova Scotia in 1992. In addition to Canadian initiatives, over the past three decades EEM programs have been carried out at many other offshore developments around the world. These have provided a wealth of knowledge about the fate and biological effects of drilling and production contaminants. Scientists at BIO felt the time was right to launch an international workshop to bring together key scientists and environmental managers to share their knowledge and experiences on EEM programs, and to discuss the successes and limitations of current EEM protocols and future research needs.

THE WORKSHOP

On May 26–29 the Offshore Oil and Gas Environmental Effects Monitoring Workshop was held at BIO, co-chaired by DFO research scientists Peter Cranford and Kenneth Lee. Over 165 individuals from 11 countries participated in scientific lectures, poster presentations, and social gatherings, to foster networking opportunities. The workshop included 80 presentations by scientists, environmental managers, and industry representatives from Canada, the United States, Norway, the United Kingdom, and the Netherlands.

Awards of $500 (donated by each of EnCana and Petro-Canada) for the best student oral and poster presentation at the workshop went to two students from the Faculty of Engineering at Memorial University of Newfoundland. Haibo Nui and his colleagues conducted a study on the transport properties of discharged synthetic-based drilling cuttings, and Thanyamnta Workakanok and her colleagues evaluated offshore drilling cuttings management technologies using multi-criteria decision making. Left to right: Urban Williams (Petro-Canada), Peter Cranford (DFO), Thanyamnta Worakanok, Lori MacLean (EnCana), Geoffrey Hurley (EnCana), Ken Lee (DFO: COOGER) Missing: Haibo Nui

The meeting began with a welcome by Dr. Michael Sinclair, the DFO Regional Director of Science at BIO. This was followed by oral presentations organized into three workshop theme sessions. The first theme, *EEM and Environmental Management*, addressed environmental management issues including risk assessment, effects monitoring, and decision-making processes. The second theme, *EEM Methodologies: Lessons Learned*, focused on applications and regional experience from ongoing EEM programs. The final theme, *EEM Methodologies and Technologies*, featured current approaches and technologies used to study benthic and pelagic impacts, including new methods for monitoring potential alterations in fish health and community structure, and the development of predictive risk assessment models. Drs. Thomas Ahlfeld of the US Department of the Interior/Minerals Management Service, Roger Green of the University of Western Ontario, and Alf Melbye of the Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology respectively provided keynote addresses to introduce each session.

The workshop was sponsored by Fisheries and Oceans Canada, the Environmental Studies Research Fund (ESRF), the Program of Energy Research and Development, Petroleum Research Atlantic Canada (PRAC), Environment Canada, the National Energy Board, the Canadian Association of Petroleum Producers, the Canada-Nova Scotia Offshore Petroleum Board, and the Canada-Newfoundland Offshore Petroleum Board. A proceedings volume containing peer-reviewed papers presented during the workshop will be published and made available through Battelle Press in 2004.

Immediately following the workshop, on May 30 a public forum, Strengthening the Linkage between Environmental Effects Monitoring and Environmental Management for the Offshore, was hosted by DFO's Oceans Sector and the Canadian Association of Petroleum Producers. As workshop rapporteur, Dr. Roger Green opened the forum with an overview of the EEM workshop. Kathleen Hedley, manager of the EEM office with Environment Canada, gave a keynote address describing environmental effects monitoring requirements under the *Fisheries Act* and lessons learned from pulp and paper mill EEM programs. She also provided insights into future EEM directions. Gary Sonnichsen (Natural Resources Canada, on assignment with PRAC) moderated a panel discussion on the relationship between environmental effects monitoring and the regulatory environment. The panel consisted of representatives from industry, academia, regulatory authorities, and non-government environmental organizations. A transcription of the panel discussion, including audience participation, is included in a technical report [Armsworthy et al; 2004, *Workshop on Offshore Oil and Gas Environmental Effects Monitoring, Bedford Institute of Oceanography, Dartmouth, Nova Scotia, May 26-30, 2003* (ESRF Report) (in press)].

Support Highlights

Research Voyages in 2003

– Donald Belliveau

Researchers at BIO utilize the following research vessels, which are operated by the Canadian Coast Guard, Maritimes Region:
CCGS *Alfred Needler*, a 50 m offshore fisheries research trawler;
CCGS *Hudson*, a 90 m offshore research and survey vessel;
CCGS *Matthew*, a 50 m coastal research and survey vessel;
CCGS *J.L. Hart*, a 20 m inshore research vessel; and
CCGS *Navicula*, a 20 m inshore research vessel.

In addition, scientists at BIO sometimes conduct field programs on other regions' research vessels, vessels of opportunity such as federal government buoy tenders and icebreakers, commercial fishing and survey vessels, and research vessels of other countries.

The CCGS *Alfred Needler*'s principal role is stock assessment surveys. Data collected during the annual multi-species ecosystem surveys are a primary source of information for fish and invertebrate stock assessments conducted by the Maritimes, Gulf, and Quebec Regions. It is used also for fisheries research programs. During February and March, the *Needler* was used for shellfish and winter groundfish ecosystem surveys on Georges Bank and the Scotian Shelf, as well as for a new groundfish research program on Brown's Bank. After its annual refit in April, the *Needler* was deployed to the Gulf of St. Lawrence where scientists collected samples for study of fish diseases. Fishery observer training was the next mission, followed by salmon studies in the Gulf of Maine. DFO Maritimes Region scientists from BIO and St. Andrews conducted the annual Scotian Shelf survey in July. Over the next month, the Northern Gulf of St. Lawrence survey was carried out by scientists from the Institut Maurice Lamontagne, Quebec Region. On August 31, a fire seriously damaged the *Needler* as it moved from the Northern to the Southern Gulf and the vessel was removed from service for the rest of the year.

CCGS *Hudson* had a busy year, with cruises scheduled from April to December. Unfortunately, refit delays caused the first cruise to be shortened, and while the annual spring Atlantic Zone Monitoring Program (AZMP) sampling was completed, the spring sampling for NORWATE, an international research program studying the distribution of zooplankton, was deferred until next year. The next cruise supported a joint DFO/university program called Surface Ocean Lower Atmosphere Study (SOLAS). During the 24-day voyage, the *Hudson* sailed from Halifax to the Sargasso Sea, north to the southern tip of Greenland, and back home to BIO. The end of May was spent on the Scotian Shelf, testing new instruments being developed

TowCam being recovered by the CCGS Hudson on the Scotian Shelf during benthic habitat studies, October 2003, Hudson Cruise 2003-059

for AZMP and servicing moorings. In June, NRCan scientists used the vessel for a habitat mapping geophysical survey on the Scotian Shelf, followed by a geohazards survey on the Grand Banks. The vessel sailed in July to the Labrador Sea to service oceanographic moorings and conduct hydrographic survey operations as part of Canada's contribution to global climate studies. Upon returning from the Labrador Sea in early August, the *Hudson* headed north again to Davis Strait in support of a joint NRCan/university program for a

seismic study of deep crustal refraction. This was followed by another NRCan-led habitat mapping geophysical survey on the German Bank. A team of BIO habitat ecologists then boarded the ship to carry out studies of the effects of offshore hydrocarbon development on Sable Island Bank and to survey deep sea coral at the mouth of the Laurentian Channel. During the latter study, the first *Lophelia* reef in Atlantic Canada was discovered. At the mid-point of this cruise, scientists from DFO Northwest Atlantic Fisheries Centre, St. John's, Newfoundland and Labrador, joined the BIO contingent for the second field season of a three-year program exploring the relationships between groundfish and their seabed habitats on Emerald, Western, and Sable Island Banks. From mid-October to early December, oceanographers from BIO and the Northwest Atlantic Fisheries Centre conducted cruises to obtain the autumn AZMP physical and biological oceanographic dataset, as well as the autumn NORWATE dataset. The final cruise of the year collected data toward the winter dataset of the NORWATE program.

CCGS *Matthew* began its season in mid-April with a cruise to the Sable Island area to study sharks. Deployment of camera systems and baited lines was proceeding well until bad weather forced the cruise to be shortened. The vessel made a quick trip to Lunenburg to deploy moorings in support of a joint DFO/Dalhousie University program. The next cruise was in support of an NRCan study of marine environmental quality in the Bras d' Or Lakes. Upon return, the installation of a new generation multi-beam survey system was completed. After a short survey on German Bank to test the system and collect data in support of NRCan research, the vessel proceeded to the northeast coast of Newfoundland for its annual hydrographic charting program. When ice conditions permitted, the ship moved to the Labrador coast to continue hydrographic surveying before returning to BIO in mid-October. The last cruise of the season was in support of an NRCan program to study dredge spoil disposition in the Miramichi region of New Brunswick. Stormy weather severely limited the amount of data collected during the cruise.

The smaller inshore fisheries research vessels, CCGS *J. L. Hart* and CCGS *Navicula*, also had busy seasons. A large number of scientists conducted a wide variety of programs including stock assessment, fisheries and habitat research, and geophysical surveys. CCGS *J. L. Hart*, operating for the most part out of the St. Andrew's Biological Station, spent the field season supporting research programs in the Bay of Fundy area. The CCGS *Navicula* served as a platform for the final year of a co-operative DFO/First Nations fisheries research program in the Bras d'Or Lakes. It also supported equipment trials, and mooring deployments near Lunenburg as part of the DFO/Dalhousie University study mentioned above. The *Navicula*'s season ended late in October.

Luckily, our research vessels fared well when Hurricane Juan brutally struck Halifax on September 28. Most were away from port. The *Matthew* was working off Labrador, while the *Hudson*, on the Scotian Shelf near the Laurentian Fan, was far enough from Halifax to continue surveying the coral reef. The *Hart* lost just a small amount of time to the high winds. The *Needler*, tied up after the fire, suffered no new damage.

As in previous years the vessels were very busy providing BIO science with platforms from which to conduct research. The officers and crews showed their usual interest in the science programs, and their enthusiastic co-operation was greatly appreciated by the researchers.

CCGS *Matthew* Sails into the 21st Century

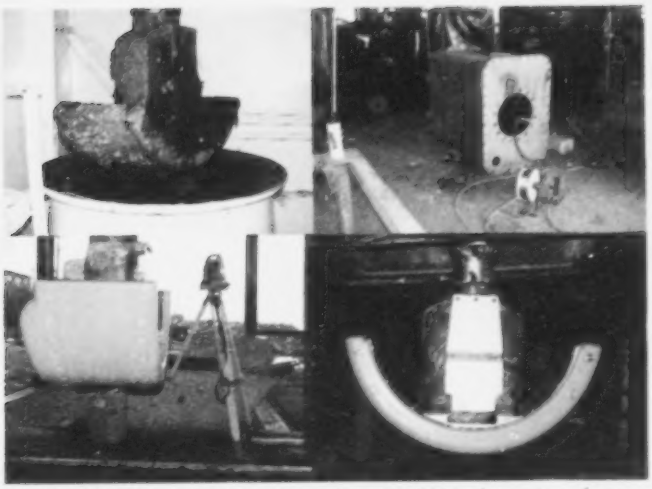
– Mike Lamplugh

The CCGS *Matthew* was designed and built in 1990 to conduct hydrographic surveys for the Canadian Hydrographic Service (CHS), replacing the CSS *Maxwell*. It was intended that the *Matthew* have state-of-the-art survey capabilities but a specification error prevented the transducer housing from accommodating the 2nd generation EM1000 multibeam system.

The Simrad EM100 system that was installed worked well for the next 13 years, although its technology significantly impacted survey capability. The operating console, based on mid-eighties personal computer technology, made support for the system increasingly difficult. In fact, this system was the last of its type operational worldwide when it was decommissioned in March, 2003. Subsequently, the sounder was transferred to the Maritime Museum of the Atlantic where it is now a centerpiece of their acoustic hydrographic display.

In January 2003, DFO staff from CHS, Finance, and the Regional Science Director's office began investigating taking advantage of the scheduled April dry-docking of the *Matthew* to replace the multibeam system. The increased efficiency of the survey operations alone would be significant, to say nothing of the higher resolution and quality of data that would be acquired. Initial funding committed by the Regional Director General enabled us to go forward. NRCan also provided financial resources. Two companies, Brooke Ocean

Comprehensive 3D survey of multibeam installation was conducted while Matthew was in drydock.



Clockwise: EM100 transducer being removed, new EM1002 trunk, two views of new EM1002 transducer installed and extended below vessel on RAM unit

Technology (BOT) and Kongsberg-Simard, were then approached about partnering with DFO to upgrade the ship's survey capabilities.

BOT's biggest product line is a series of "freewheeling" hydraulic winches, called Moving Vessel Profilers (MVPs), that allow the acquisition of data (sound velocity profiles to calibrate the multi-beam) from the water column while the vessel is underway. BOT are also developing a new product, the Free Fall Cone Penetrometer (FFCPT), which has been tested extensively with stationary deployments, but not from an MVP or while a vessel is underway. Working jointly with CHS on the *Matthew* upgrade was an opportunity to take their development work to the next level.

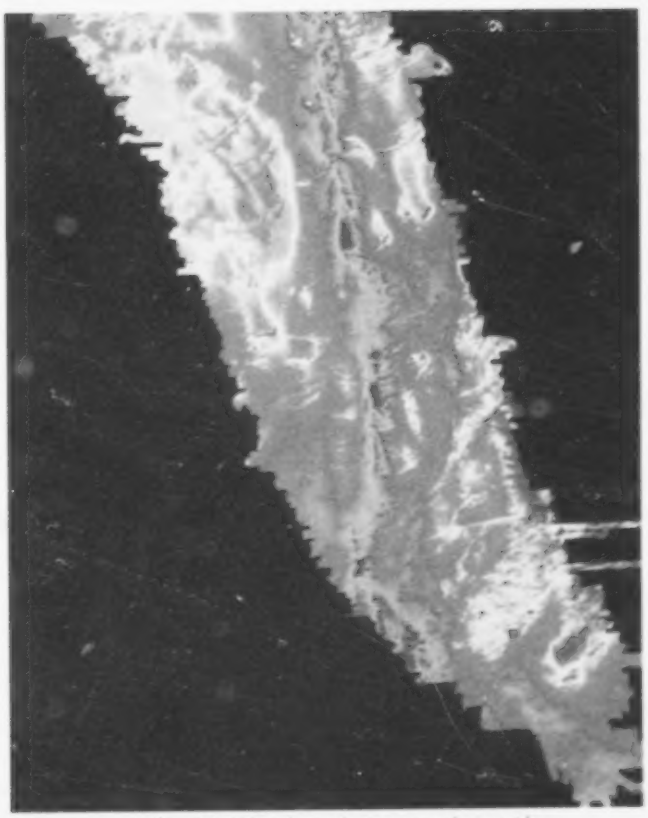
Kongsberg-Simrad had field tested their 3rd generation EM1002 system only in the cool waters of Norwegian fiords, so when their first delivered systems were deployed in warmer climates they encountered unforeseen problems. The company seized the opportunity to work jointly with DFO and to have a North American test-bed for the 4th generation EM1005

The Joint Project Agreement (JPA) has a three-year timeframe. In 2003, a Simrad EM1002 was installed to gather data as a test-bed for future evaluations. A BOT MVP-200 with a multi-sensor fish will be installed in 2004. The sensors will be Sound Velocity Profile (SVP), Conductivity, Temperature, and Density (CTD), and a Fluorometer. These last two data streams will support DFO's Ocean Physics Group in the Atlantic Zone Monitoring Program. In 2005, the "topsides" of the EM1002 system will be upgraded to the EM1005, which will be able to capture acoustic returns in the water column (biomass) in addition to bathymetry and backscatter. In years two and three of the JPA, dedicated testing and evaluation of the newly installed equipment will be included in the vessel's assignments. All parties will share the results from these trials.

The groundwork was set to modernize the *Matthew*; the challenge now lay in implementation. The first obstacle was the sudden decision to move the dry-docking date forward a month. The next few weeks were a flurry of activity. Marine architects had to be retained to construct blueprints for the hull fitting (trunk) required to house the larger transducer; these tasks had to be coordinated with CCG staff for inclusion in the shipyard work. Meanwhile, the JPA among the three parties had to be finalized and signed. Despite the very tight timeline, the commitment by all involved was rewarded. All required paperwork and materials were in place when the vessel went into the Shelburne Shipyard. That is not to say a significant number of risk management decisions were not taken!

Work went well in Shelburne where shipyard staff were very helpful and cooperative. The larger transducer trunk, rebuilt ram (the ram unit extends below the vessel bottom to place the transducer below all hull interference), and new transducer were installed in parallel with the scheduled vessel maintenance. Even a last-minute opportunity to apply a very specialized (acoustically transparent) anti-fouling system to the transducer and trunk area was realized. The water alongside the BIO wharf has proven to be very conducive to marine growth on ships wintering there. Significant mussel and barnacle growth has required divers to check and clear the acoustic surfaces each spring. It is hoped the anti-fouling application will minimize this work and improve the overall quality of the sounding data.

The *Matthew* arrived back at BIO on April 2. The task then was to install and test the topside equipment prior to the scheduled June start of the CHS survey season. This process was complicated by the fact that two non-CHS cruises were scheduled prior to June 1. The CCG carpentry crew at BIO did an excellent job of building the ergonomic work areas in the survey room aft of the bridge. The BIO marine technicians coordinated with Simrad staff to install the EM1002 system electronics. An Applanix POS-MV 320 positioning and orientation system was also supplied. All this equipment was installed and operational by June 10. The *Matthew* sailed the next day for an evaluation/testing trip on German Bank. Despite a few inevitable hiccups, the data acquired are exceptional, and were used in support of a DFO Fisheries Management initiative in Scallop Fisheries Area #29 (SFA29) off Southwest Nova Scotia.



Imagery generated from EM1002 evaluation/testing trip on the east side of German Bank: area surveyed is approximately 17 by 6 nautical miles

The *Matthew* then proceeded to the northeast Newfoundland coast to conduct surveys north off Fogo Island, and to complete hydrographic survey operations started in 2002 between White Bay and Hare Bay (eastern side, Great Northern Peninsula). The modern surveying of this complex area has been ongoing since the 1970s. The increased efficiency of the EM1002 multibeam system over the EM100 (swath widths are four times wider) allowed the remaining work to be completed this year. This significant achievement allows the three 1:150,000 charts between Bonavista Bay and St. Anthony to be produced. They will replace CHS Chart 4520, which is unusable with Global Positioning Systems because of the multiple unknown horizontal datums employed in its construction. Mariners will also welcome finally having Electronic Navigation Charts, or ENCs, available in this area.

This state-of-the-art surveying capability has taken the *Matthew* from a first to a fourth-generation multibeam-sounding platform in one large leap. It will allow CHS to collect high quality data in support of our mandate to produce navigational charts for the marine community, and to provide a valuable data stream in support of a wide variety of related marine endeavours and disciplines.

Remaking the Major Facilities at BIO

– Mark Chin-Yee

The previous two BIO Reviews have included articles describing the rejuvenation of the berthing facilities and the new heating and cooling plants that will service the Institute complex. These projects are two in a series aimed at revitalising the BIO facilities, some of which are more than forty years old. In 2003, we started work on the BIO complex itself with extensive renovation to the north end of the Vulcan Building. This article outlines the revitalisation plan for BIO and provides an overview of what is to come.

Demolition and construction work on the Canadian Coast Guard's Technical Services workshops began in November, 2003. Under the direction of Public Works and Government Services Canada (PWGSC), the architects and engineers have worked closely with the user groups to redesign the building. The activities in this area of the Vulcan Building are industrial in nature and production oriented. Particular attention to workflow, safety, and health, will result in an efficient and pleasing workshop environment. In the spring of 2004, renovation will commence on the rest of the interior space for the science and electronic workshops, and the shipping and receiving area for BIO.

The science community at BIO has long awaited the construction of a new laboratory. That dream is one step closer to fruition. The architecture firms of John K. Dobbs and Associates (Halifax) and Shore Tilbe Irwin and Partners (Toronto) have been hired to design a state-of-the-art laboratory. The labs will meet Level II bio-safety containment standards, and are being designed to be easily reconfigured to meet changing program requirements. The firms are developing concepts based on three objectives: (1) flexibility to change the laboratory layout; (2) abundant use of natural light; and, (3) reducing the environmental impact of the construction and operation of the building. The schedule calls for the first phase of construction to begin by the fall of 2004, with occupancy slated for 2006.

Vulcan Building construction

Bedford Institute of Oceanography - 2001

Preparations are also well underway for the complete renovation of the van Steenburgh Building. This building will be converted from the present inefficient mix of labs, workshops, and offices to a modern office complex that will accommodate researchers, engineers, technicians, and administrative staff. The renovation will start after the new Level II laboratory has been completed. There are also plans to renovate the Strickland Building to dry labs and workshops for science and other technical programs.

Remaking our facilities to meet the challenges of an integrated world-class research institution is our ultimate goal.

Special Programs

The Partnership for Observation of the Global Oceans (POGO)

– Shubha Sathyendranath

2003 POGO meeting in Yokohama. BIO's Shubha Sathyendranath is seated, front centre.

Leading oceanographers, representing a dozen of the world's largest ocean research programs and institutions, met in Yokohama, Japan, November 22-24, 2003. Hosted by Japan Marine Science and Technology Center (JAMSTEC), this was the fifth meeting of POGO, an independent consortium established in 1999 to promote long-term cooperation in understanding and observation of the global oceans. BIO is a member of POGO and hosts the POGO Secretariat.

At this conference, POGO leaders forged a strong, global commitment, over the next ten years, to the implementation of the ocean component of an Earth Observation System. To accomplish this effort, POGO created and endorsed the "Yokohama Declaration" to ensure that appropriate measures are taken to increase major observations of the global oceans.

More than 71% of the planet is covered by oceans. These oceans are vital to the survival of all life on Earth. It is crucial—now, more than ever—to implement an earth system approach, linking the oceans, land, life, and atmosphere. As a coordinated organization, POGO has the capacity to implement long-term sustained observations of the oceans that will benefit the oceans and mankind.

Critically needed are observations within water, such as those obtained from an armada of undulating probes. Called Argo, these probes would be deployed all over the world, measuring various physical and other properties of the oceans including temperature and salinity. Also envisioned is a network of observatories, situated at critical points around the world's oceans, which would measure a comprehensive suite of physical, chemical, biological, and geological properties of the entire water column.

These in-water observations are seen as tools complementary to observations made globally through man-made space satellites capable of observing several physical and biological properties of the oceans on the global scale. Since satellite capabilities are typically limited to observing only the surface layers of the oceans, and because

they are not able to measure all critical properties, the oceanographers at the Yokohama meeting are convinced that both remote sensing by satellites and in-water measurements are necessary to complete the observing system. These observations will serve the need for data for various computer models that are designed for understanding and predicting the state of the oceans in the future. Such models are also designed to serve a variety of practical applications, including an understanding of the role of the oceans in climate change, prediction of long-term climate and extreme weather events, and management of living resources from the sea.

POGO members are committed to implementing a comprehensive system for observing the oceans on the global scale, effective immediately. With the strong endorsement of the Intergovernmental Oceanographic Commission, POGO has created essential links with many national and international organizations that deal with marine science. POGO leaders carried their message to the meeting of the Group on Earth Observations (GEO) in Baveno, Italy, in November 2003. GEO was created as a result of the G8 Declaration in Evian, France, last summer to implement an Earth Observation System over the next ten years. Many countries in addition to the G8 nations have joined GEO, thus declaring their commitment to the goal. POGO is now a participating organization in GEO.

The BIO-Hypatia Project Influences National Initiatives

– Sherry Niven

In 2003, the BIO-Hypatia Project took centre stage in the development of national initiatives to increase the representation and career progression of women in Science and Technology (S&T), both within the federal government and in the broader S&T community.

Insights from the BIO project have guided the work of the Federal Women in S&T Working Group. This group, composed of senior public servants from Science Based Departments and Agencies, was formed in 2002 to develop an action plan on behalf of women in federal S&T. Sherry Niven (DFO) and Ross Boutilier (NRCan) of the Hypatia team are key members. (*See* http://intranet.sciencetech.gc.ca/WomeninS&T/womeninst_e.shtml.)

The Working Group held a workshop at BIO on June 16, 2003 to learn more about the framework and processes used in the BIO-Hypatia Project. They also discussed carrying out Hypatia-like studies in other S&T workplaces. "Best practices" at the Canadian Space Agency (CSA), Defence Research and Development Canada, the National Research Council (NRC), and Environment Canada (EC) were presented. The Hypatia facilitation process was used to build on this information and determine the best means of achieving the Working Group's strategic objectives.

A key outcome was the strengthening of the Women in S&T network across the country. Of particular note is the partnership that has developed between BIO and the CSA. Engineers at the Space Agency have used insights from the Hypatia Project in their action plan to increase the representation and participation of women in the Science, Technology, and Management (STM) streams of the CSA. Marc Garneau, CSA President, is championing the CSA Women in STM initiative and, in an address to the Agency, has committed to "providing a level playing field that allows for the meritorious advancement of women through the CSA hierarchy."

The workshop attracted participants from across the country. These included approximately 60 members of the federal S&T community, from 12 departments and agencies, as well as representatives from women in S&T groups, academia, industry, and provincial governments. Results from the workshop are being used by the Working Group to develop their policies and to make recommendations to the leaders and decision makers of the federal S&T workplace, as they were tasked to do.

The BIO-Hypatia Project has become widely viewed also in the private sector as a best practice and valuable model for: identifying the factors in the workplace limiting the recruitment and retention of women in S&T (as well as in other Employment Equity groups), developing a plan of action to address these factors, and bringing about the transformational change required in the culture of S&T workplaces to accommodate the increased diversity, as well as to benefit scientifically from the increased diversity of perspectives and approaches.

Consequently, members of the BIO-Hypatia Project team have been invited to participate in a number of national initiatives related to women in S&T, most notably: 1) the formation of Association de la francophonie à propos des femmes en sciences, technologies, ingénierie et mathématiques (AFFESTIM), a new group for francophone women. Marie-Claude Williamson (NRCan liaison for the BIO-Hypatia Project) is a founding member of AFFESTIM and a member of the Executive Committee for 2004-05. (*See* http://www.moifem.ca/Moifem/femmes-stim.html.) and 2) consultations by the Canadian Coalition of Women in Engineering, Science and Technology (CCWEST), a national coalition of

Break-out group at the BIO-Hypatia Workshop, counter-clockwise from the flipchart: Sherry Niven (DFO), Mark Williamson (NRCan), Chantal Couture, (EC), Charlotte Keen (NRCan), and Margo Burgess (NRCan)

groups that promote women in science, engineering, mathematics, technology, and trades. The 2003 consultation project was WinSETT (Women in Science, Engineering, Trades and Technology): Building Communities, with the purpose of expanding the CCWEST network and increasing its advocacy role. (See http://www.ccwest.org/sett/sett.asp.) A noteworthy outcome of WinSETT was its pointing out that the Canada Innovation Strategy did not acknowledge the important present and future economic and social contributions of women in SETT, nor the lost potential resulting from their under-representation. WinSETT rallied a network, rich in expertise and experience (involving government, academia, labour, and NGOs), to work together to ensure that equal opportunities in SETT are provided to women, so that Canada can benefit from the full potential of its populace.

Break-out group during the BIO-Hypatia workshop of June 16, 2003, clockwise from the flipchart: Marie-Josée Bourassa (CSA), Gina Parsons (DFO), Marie-Claude Williamson (NRCan), Hiromi Matsumi (Simon Fraser University; the Canadian Coalition of Women in Engineering, Science, and Technology), Fred Donaldson (Public Service Commission), Jacob Verhoef (NRCan), Kathleen Flemming (Canadian Coast Guard, DFO), Dale Nicholson (Canadian Hydrographic Service, DFO), Andy Sherin (NRCan), Mary Williams (NRC), Sonya Dehler (NRCan), and Patrick Potter (NRCan)

2003 was an important year for national initiatives towards increased representation of women in S&T in Canada. This need became widely recognized and the CCWEST became "the voice" for women in SETT in Canada, prepared to advise government and other sectors on building the human resource capacity of women in SETT careers. In her closing comments at the National WinSETT Forum, Dr. Margaret-Ann Armour (Past President of the CCWEST and Assistant Chair of Chemistry at the University of Alberta) declared, "The opportunity is now and we are here, ready to meet that opportunity." The BIO-Hypatia Project has significantly contributed to making this so.

The BIO-Hypatia Project is a community-led, management-supported initiative to identify, examine, and address factors limiting the participation of women in S&T at BIO. The project was initiated in 2001 with the focus on identifying and changing cultural factors that limit the participation and advancement of women in the workplace. The ultimate goal of the Project is to build awareness of the value of diversity to science and to make changes that promote diversity within the S&T community.

BIO: Within Our Communities

BIO Outreach 2003

- Joni Henderson and Jennifer Bates

The guided tour program at BIO enjoyed its busiest season ever in 2003, with over 4,500 visitors taking the tour between March and August. One thousand more took the self-guided tour. The guides continued to modify the route to better represent the Institute. As a result of feedback from tour evaluation forms, the following changes were implemented during the summer of 2003:

- a permanent exhibit highlighting some of the deep-sea corals found off the coast of Nova Scotia was put in place;
- a wall panel describing work by DFO staff on the Sable Island Grey Seal population was installed;
- a high quality pop-up display outlining the role of the Centre for Offshore Oil and Gas Environmental Research (COOGER) was added to the tour;
- to complement the COOGER display, oiled rocks from the 1970 *Arrow* spill in Black Duck Cove were exhibited in front of posters depicting natural oil degradation and various remediation techniques;
- a model which illustrates ice keels and their threat to oceanic pipelines was installed in front of a multibeam image of ice scours in the Beaufort Sea; and
- changes were made to the mini-theatre where visitors can choose from a selection of BIO-produced films. As a result of the recent proposed designation of The Gully as Canada's first east coast Marine Protected Area, the film about The Gully will be complemented by a series of highly visual, informative posters on the various marine life found in this unique canyon.

Development is underway on an exciting new exhibit on "Species at Risk" that will highlight local species such as the Right Back Whale, the Atlantic Whitefish, Inner Bay of Fundy Salmon, and the Leatherback Turtle. As a result of the ever increasing demand for guided tours, plans include the addition of a year-round bilingual tour.

DFO Associate Director Science/Coordinator RAP Bob O'Boyle visits an exhibit at the Team Nova Scotia Science display at BIO

FISHERIES AND OCEANS CANADA

In April, staff were pleased to host Team Nova Scotia, comprised of a group of grade 7-12 students from across the province, each of whom had taken top prize at Science Fairs in their respective districts and categories. Over the two-day exhibition period, students explained their projects to BIO staff who, in turn, provided them with valuable feedback. The exhibition was part of a team-building exercise for the students before they left for Calgary where they represented Nova Scotia at the Canada-wide Science Fair. Dr. Mary Anne White of Dalhousie University rounded out the Team Nova Scotia event with a captivating talk on materials science.

Despite heavy workloads, DFO staff continued to provide impressive support to schools. Job shadowing requests were innumerable yet most were accommodated. The efforts of employees such as Paul Dickie, Ocean Sciences Division, who hosted more than 100 students while carrying out data collection/analysis for the Bedford Basin Plankton Monitoring Program, are testament to our staff com-

Team Nova Scotia – on their way to the Canada-wide Science Fair

mitment to education within our community. In addition, a number of co-operative education high school students benefited from BIO placements that enabled them to receive their science credit. As before, staff were in demand to provide presentations on a variety of scientific disciplines to schools, universities, and the general public.

In August, 22 "Oceans 11" teachers took advantage of a professional development opportunity when they attended a two-day summer institute co-hosted by DFO and the Nova Scotia Department of

Gordon Fader gives a commentary on Halifax Harbour to the Oceans 11 group.

Hands-on learning for Oceans 11 participants

EDGEO Workshop 2003

Education. Activities included fish identification and ageing techniques, phytoplankton cultivation, and chart navigation—all of which could be duplicated by students in the classroom. The two-day event was capped with a tour of Halifax Harbour on board CCGS *Sir William Alexander* with commentary by Gordon Fader and Bob Miller of Natural Resources Canada.

NATURAL RESOURCES CANADA

"You really brought this topic to life!" "All the handouts are just fantastic." "You are making a valuable contribution in facilitating learning for teachers and students in Nova Scotia."

These are a few comments from participants in the Nova Scotia EdGEO Workshop Program, which is co-ordinated by outreach geoscientists at the Geological Survey of Canada (Atlantic) of Natural Resources Canada (NRCan), with fellow members of the Nova Scotia EdGEO Workshop Committee. In August 2003, the group hosted its tenth teachers' workshop. Twenty-eight teachers travelled from locations throughout Nova Scotia to attend the two-day workshop at the Fundy Geological Museum in Parrsboro. The program included interactive presentations on the basics (rocks and minerals, fossils, dinosaurs, and geological time) plus sessions on soil, climate change, and oil and gas. Two half-day field trips, one of which was to the world famous Joggins site, allowed teachers to apply what they learned in the workshop. This program is very popular with the education sector, attracting teachers as well as those involved with museum programs, science centres, and private sector educational services.

EdGEO is a national program that supports local workshops on earth science for Canadian teachers. It is co-ordinated by the Canadian Geoscience Education Network of the Canadian Geoscience Council, and funded by various earth science-related associations. The EdGEO workshops aim to provide educators with enhanced knowledge, classroom resources, and increased confidence. By providing educational opportunities for today's teachers and, through them, their students, EdGEO workshops cultivate a heightened awareness and appreciation of our planet.

While the National EdGEO Program funded the workshop, in-kind support was generously provided by the Geological Survey of Canada (Atlantic), the Nova Scotia Department of Natural Resources, Dalhousie University, the Annapolis Valley and Halifax Regional Municipality school boards, Atlantic Science Links Association, the Fundy Geological Museum, and the Nova Scotia Department of Education. We will celebrate the 10th anniversary of the EdGEO Program at our eleventh workshop, to be held at the Bedford Institute of Oceanography August 23-25, 2004.

Two successful NRCan outreach activities have resulted from the popular geology book *The Last Billion Years: A Geological History of the Maritime Provinces of Canada*. One is the well-attended talk series, hosted by the Atlantic Geoscience Society and now in its third year at the Nova Scotia Museum of Natural History in Halifax. The public continues to set record level attendance for these talks on geology of the Maritime Provinces. The second is a poster series based on some of the wonderful paintings created for the book. *The Evolving Maritimes* poster is now available, and the second will be titled *The Mastodons of Nova Scotia*.

NRCan geoscientists continue to revitalize EarthNet (earthnet.bio.ns.ca), a virtual resource centre of earth science resource information and contacts for teachers, home educators, and students at all levels. As in previous years, we give invited talks at schools, universities, and libraries, and collaborate with museums, science centres, societies and associations, and other government agencies to develop outreach products and activities that assist educators in bringing earth science into the classroom and heighten the public's understanding of our dynamic Earth.

Community Assistance in 2003

– Andrew Stewart, DFO and Maureen MacDonald, NRCan

As in previous years, staff and retirees of BIO generously supported the community with their time and financial donations.

The largest organized charitable event is the Government of Canada Workplace Charitable Campaign (GCWCC), where federal public servants can give to United Way/Centraide, Health Partners, or any registered charity in Canada. In 2003, the GCWCC at BIO raised $60,901, under the direction of account executives Rhonda Coll of DFO and Maureen MacDonald of NRCan. The success of the campaign depends upon employee contributions, solicited this year by 25 energetic BIO volunteers. Staff from the three other departments at BIO—Environment Canada, National Defence, and Public Works and Government Services Canada—contributed through their off-site departmental offices.

A portion of our GCWCC contribution was raised through the following enjoyable events:

- In January, BIO staff participated in a multi-departmental Internet auction.
- The golf tournament, held at Hartlen Point Forces Golf Club in October, was organized by BIO employees, and included guests from the Canadian Food Inspection Agency, and DFO's Burnside warehouse, Marine House, and Canadian Coast Guard.
- NRCan put on a Hallowe'en pumpkin carving contest with lots of fun and good food.
- Throughout November, library staff managed the yearly sale of donated books.
- The 13th annual hockey game, family skate, and Christmas party was held in December.

Lining up a putt was critical at times and involved the entire team. The 18 teams of four golfers each seemed to have a good round, judging by their wind-burned, smiling faces and big appetites.

Entertaining special events, many of which have become yearly affairs, garnered donations for other charities:

- In March, the auditorium was transformed into an intimate

BIO employees participating in the annual "Christmas gift of giving" at the food bank

cafe setting for the fifth annual *Beat the Winter Blues* concert in support of the Parker Street Furniture and Food Bank. The music was an eclectic mix offering something for every taste. Of special note were performances by a string quartet and a Mozart horn quintet from Symphony Nova Scotia. The event featured a showcase of arts and crafts by BIO staff and their families.

- A food and winter clothing drive was held for the Food Bank.
- For our annual "Christmas Gift of Giving", volunteers from BIO worked at the Food Bank assembling and delivering boxed Christmas dinners.
- The Canadian Cancer Society's spring sale of daffodils was popular, as usual.
- The Marine Environmental Science Division has been raising funds for needy families at Christmas through coffee parties, raffles, and bottle recycling. This year they provided food and gifts for 15 people.
- Many at BIO support the Society for Prevention of Cruelty to Animals (SPCA). Lynn Doubleday of the BIO cafeteria raises funds for the SPCA, as well as accepting donations of supplies for the shelters.
- Several divisions choose their own charities and support them through Casual Days and other means.

The generosity of BIO staff and retirees and their participation in the community help define the character of the Institute. Thank you to all of those individuals and teams who raised funds and organized the special events.

The BIO-Oceans Association: Actions and Accomplishments in 2003

– David N. Nettleship, President

The year 2003 was an outstanding one for the Bedford Institute of Oceanography - Oceans Association (BIO-OA). While the first four years set the foundation of the organization and the fifth firmed up short-term goals, the sixth (2003) became the test year to determine how achievable were those goals. We were gratified to have made considerable advancement on all four major tasks. In the case of Archives policy and procedures, our achievements exceeded our goals.

The BIO-OA Work Plan for 2003 identified four major tasks: the Archives "March" (development of the Archives policy), collection of Archives materials, Beluga Award nominations, and membership growth.

LIBRARY ARCHIVES

Given BIO's pivotal role in the development of 20th century oceanography, and the Institute's contributions to marine problem-solving, the OA identified the requirement for an on-site library archives. Its principal function is to organize and curate materials on the history of scientific investigations at BIO over the past 40 years. The collection will include cruise reports, contributions to national and international scientific organizations, and biographical information on the research and technical support staff. This material will serve as a complementary resource to the formal published record of Canada's contributions to oceanography, marine biology, marine geology, and marine geophysics.

The ratification of a BIO Archives Policy—spearheaded by BIO Archivist Librarian Marilynn Rudi and Dr. Bosko Loncarevic, Chair of the OA Library Archives Committee—represents an opportunity to preserve materials of historic importance to BIO. The establishment of official guidelines for acquisitions and accession forms for archival library materials represents real progress towards a formal BIO Archives. A similar index-form system for archival photographic materials is being set up by Ms. Rudi and the OA Photo Archives Committee (Michael Latrémouille, Chair).

EQUIPMENT/ARTIFACTS ARCHIVES

The late 20th century technological explosion was a catalyst for numerous in-house ocean engineering innovations in support of research in oceanography, marine geology, and marine geophysics. Since 2000, the OA has concerned itself with BIO's historical "footprint", and identified a deficiency with respect to an equipment archives. Representative samples of obsolete instrumentation needed to be identified, conserved, and organized to show the evolution of BIO ocean engineering activities and marine science tools. A strong consensus was that these technological achievements are testimony to the ingenuity of BIO scientific and technical staff and are valuable for public education.

In 2003, the Equipment/Artifacts Archives Committee (Dr. Charles Schafer, Chair) completed an initial audit of obsolete equipment throughout BIO. In a preliminary test, emphasis was on cataloguing holdings within NRCan. Completed in July, the search uncovered 33 major archival pieces, indicating that at least seven thematic displays could show how engineering and science are intertwined in the quest for new knowledge of the oceans, and how hard-

From left: David Nettleship, Anna Fiander (Chief of BIO Library Services), Marilynn Rudi, and Bosko Loncarevic look over an archived map. Photo by Michael Latremouille

ware and instrumentation have contributed greatly. A detailed proposal for the BIO-OA Equipment/Artifacts Archives Project will be submitted to BIO managers.

2003 BELUGA AWARD

At the BIO-OA Annual General Meeting on May 22, Arthur Cosgrove, head of the DFO Drafting and Illustrations Group, was awarded the prestigious BIO-OA *Beluga Award* for 2003 in recognition of his leadership and contributions to excellence in scientific illustrations.

MEMBERSHIP ACTIVITIES

Membership in the Oceans Association continues to grow, numbering 172 at the end of 2003. Throughout the year, we enjoyed many interesting educational and social activities. The Annual General Meeting featured informative work program reviews and summary presentations. Highlights of the OA Seminar Series were the unforgettable lectures, *Big Sharks, Small Sharks and More Sharks off Atlantic Canada* by Dr. Steve Campana and *So You Want to Manage the Seabed ...?* by Gordon Fader. Our Social Activities Committee (Jackie Dale, Chair) co-ordinated diverse seasonal outings—Gallery of Nova Scotia visit, spring seminar and social, Halifax-Chebucto harbour cruise, St. Margaret's Bay barbeque, the Portobello Locks tour, and fall seminar and social. In December we joined BIO staff at their annual Christmas Party. In recognition of his more than 25 years of outstanding service to BIO, Michael Friis was elected the Oceans Association's first *Honorary Life Member* upon his December retirement. Of continuing importance, our quarterly *BIO-OA Newsletter* grew in size, quality, and diversity of articles.

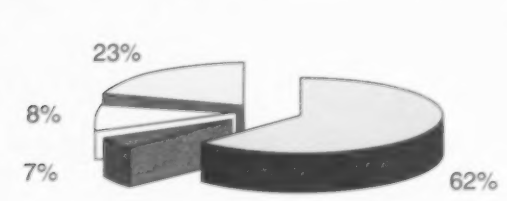
The strides forward that the BIO–OA has made on its priority work goals was the highlight for 2003. We are looking forward to continuing success in our archival endeavours and in enjoyable social events. We welcome new members and encourage all to visit our website for additional information (www.bedfordbasin.ca) and to request a complimentary copy of the current *BIO-OA Newsletter*. Come along, join up, have fun, and contribute to the aims of the Oceans Association of the Bedford Institute of Oceanography.

Bruce Wile, and Charles Schafer show two 1960s vintage instruments that could form part of a BIO Equipment/Artifacts Archive. Such instruments have contributed greatly to our understanding of the oceans. Photo by Michael Latremouille

Financial and Human Resources

Where the Institute obtains funding and how it is spent

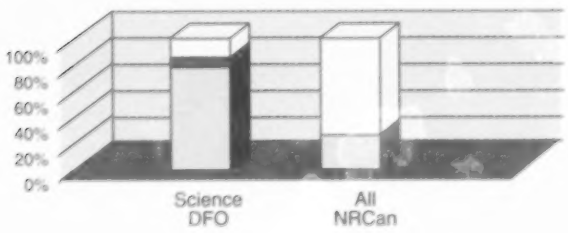
Annual appropriation from government by parliamentary vote



DEPARTMENT	SECTOR	AMOUNT ($000)
DFO	Science	29,701
DFO	Oceans & Env.	3,410
DFO	Informatics	3,835
NRCan	All	10,847

Environment Canada and DND have staff working at BIO. These resources are not captured in the above figures.

Other sources of funding



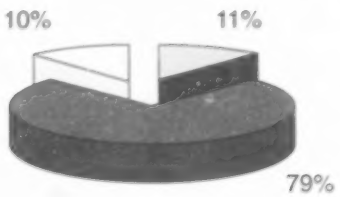
DEPARTMENT	SECTOR	GOVERNMENT ($000)	INSTITUTIONS ($000)	INDUSTRY ($000)
DFO	Science*	9,526	861	2,534
NRCan	All	890		2,000

Industry Institutions Government

Science Oceans & Environment

Program spending

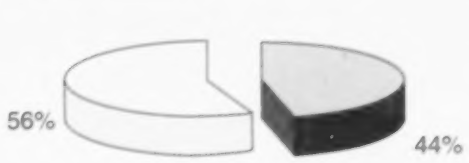
DFO Science



SECTOR	AMOUNT ($000)
Environmental Science	4,584
Fisheries & Oceans Science	34,069
Hydrography	4,529

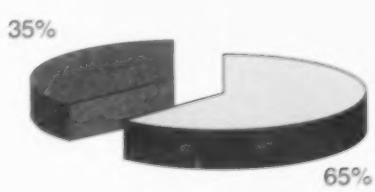
Program spending cont.

DFO Oceans and Environment



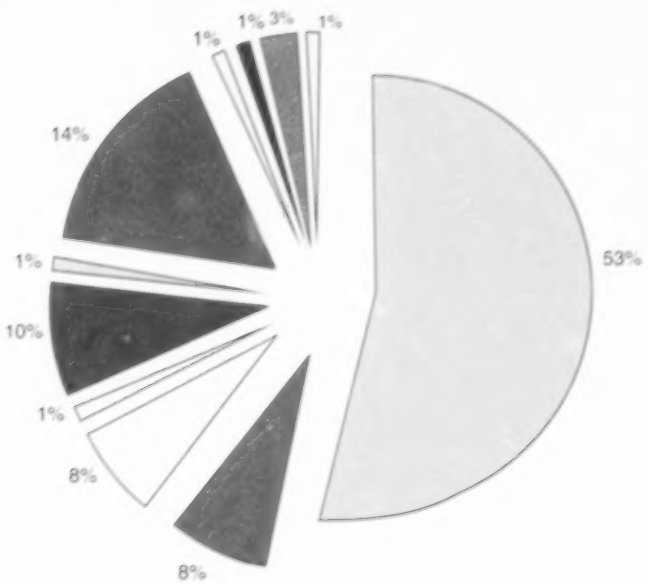
SECTOR	AMOUNT ($000)
Habitat Management	1,492
Oceans	1,916

NRCan



	AMOUNT ($000)
Research	8,350
Technology/Equipment	4,497

BIO staff by department/division



DFO - Science	351
DFO - Oceans & Environment	53
DFO - Informatics	54
DFO - Other	7
DFO - Coast Guard Tech Services	70
DFO - Aquaculture Coordination	5
NRCan - GSC Atlantic	95
EC - Operational Laboratories	4
DND - Survey Office	10
PWGSC - Site Operations	12
Research Coordination Units	10
Total	671

The numbers are taken from the staff list and do not include contractors, students, visiting scientists, or emeritus scientists.

People at BIO in 2003

DEPARTMENT OF NATIONAL DEFENCE

LCdr Robert Smith
LT (N) Scott Moody
CPO2 Ian Ross
PO1 Wendy Martin
PO2 Ron Clark
PO2 Jeff Sooley
MS Krista Ryan
MS Daisy LaCroix
LS Sean Truswell
LS Kenny Ingram

ENVIRONMENT CANADA

Margot Boudreau, Student
Christopher Craig
David MacArthur
Robby MacLeod, Student
Laura O'Connor, Student
Diane Tremblay
Jamie Young

FISHERIES AND OCEANS CANADA

Canadian Coast Guard – Technical Services

Systems Engineering Group
George Steeves, Supervisor
Garon Awalt
Arthur Cosgrove
Kelly Bentham
Bob Ellis
Bruce Julien
Francis Kelly
Mike LaPierre
Daniel Moffatt
Glen Morton
Neil MacKinnon
Val Pattenden
Todd Peters
Nelson Rice
Greg Siddall
Leo Sutherby
Heinz Wiele*

Marine Electronics
Jim Wilson, Supervisor
Gerry Dease
Mylene DiPenta
Don Eisener
Jason Green
David Levy
Robert MacGregor
Richard Malin
Morley Wright
Mike O'Rourke
Mark Robbins

Vessel Support
Andrew Muise, Supervisor
Adam Butt
Stephen Eisener
Kirby Fraser (secondment)
Tom Hann (secondment)
Richard LaPierre
Lawrence Morash (secondment)
Steve Myers
Lloyd Oickle
Bill Preston*
Harvey Ross
David Usher

Marine Aids and Maintenance
Phil Nelson, A/Coordinator
Jim Corbin
Martin LaFitte
Leonard Mombourquette
Richard Myers
Raymond Smith

Dartmouth Technical Workshop
Paul Mckiel, Supervisor
Lorne Anderson
Barry Baker
Bob Brown
Ray Clements
Allen Crowell
Peter Ellis
Milo Ewing
Brian Fleming
Heather Kinrade
Susan Kolesar
Susan Lever
Pat Lindsay
Andrew Malloy
Doug Murray
Bonaventure Nzeyimana
Derek Oakley
John Reid
Tom Roberts
Helmut Samland
Dave Somerton
Mike Szucs
Phil Veinot

Canadian Coast Guard – Operational Services

Michelle Brackett

Science Branch

Regional Director's Office
Michael Sinclair, Director
Marie Charlebois-Serdynska
Richard Eisner
Dianne Geddes
Sharon Morgan
Ann Nicholson
Bettyann Power
Carla Sears

Canadian Hydrographic Service (Atlantic)
Richard MacDougall, Director
Bruce Anderson
Carol Beals
Dave Blaney
Frank Burgess
Bob Burke
Fred Carmichael
Mike Collins
Chris Coolen
Gerard Costello
Andy Craft
John Cunningham
Elizabeth Crux

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2003.
*Retired in 2003.

Hubert Dominix
Tammy Doyle
Theresa Dugas
Helen Dussault
Steve Forbes
Doug Frizzle
Jon Griffin
Ian Hamilton, Student
Judy Hammond
Jolette Hannon
James Hanway
Malcolm Jay*
Roger Jones*
Heather Joyce
Glen King
Mike Lamplugh
Christopher LeBlanc
Scott Lewis
Bruce MacGowan
Carrie MacIsaac
Grant MacLeod
Clare McCarthy
Dave McCarthy
Paul McCarthy
Mark McCracken
Dale Nicholson
Larry Norton
Stephen Nunn
Charlie O'Reilly
Nick Palmer
Richard Palmer
Paul Parks
Stephen Parsons
Bob Pietrzak
Vicki Randhawa
Craig Reath (from PW)
Doug Regular
Gary Rockwell
Glenn Rodger
Dave Roop
Tom Rowsell
Chris Rozon
Mike Ruxton
Cathy Schipilow
June Senay
Alan Smith
Andrew Smith
Nick Stuifbergen
Michel Therrien
Herman Varma
Wendy Woodford
Craig Wright
Craig Zeller

Diadromous Fish Division
Larry Marshall, Manager
Peter Amiro
Rod Bradford
Henry Caracristi
Andrea Cox
Julie Crack
Jamie Gibson
Carolyn Harvie
Phil Hubley
Eric Jefferson
Jeanette Johnson
Dave Longard
Andrew Newbould
Darcy Pettipas
Shane O'Neil
Patrick O'Reilly
Kimberley Robichaud-LeBlanc
Karen Rutherford
Debbie Stewart
Kathi McKean Sweet
Daisy Williams

DFD Offsite:
Leroy Anderson
Mary Allen
Doug Aitken
Judy Anderson
Krissy Atwin
Denzil Bernard
Bev Davison
Claude Fitzherbert
Jason Flanagan
David Francis
Steven Godfrey
Trevor Goff
Randy Guitar
Dora Hatt
Ross Jones
Craig Keddy
Beth Lenentine
Phillip Longue
Danielle MacDonald
William MacDonald
Sheehan McBride
John Mallery
Andrew Paul
Robert Pelkey
Greg Perley
Darcy Pettipas
Rod Price
Christie Robinson, Student
Francis Solomon
Louise Solomon
Brian Sweeney
Michael Thorburne
Malcolm Webb
Ricky Whynot
William Whynot
John Whitelaw
Gary Whitlock

DFD- Gulf Fisheries Center
Paul LeBlanc

Invertebrate Fisheries Division
René Lavoie, Manager
Jerry Black
Shawna Bourque
Victoria Burdett-Coutts
Liqin Cao
Clare Carver, Volunteer
Manon Cassista
Amy Chisholm
Ross Claytor
Andrew Cogswell
Michele Covey
Ron Duggan
Cheryl Frail
Jeffrey Goddine, Intern
Billy Goodyear, Intern
Raj Gouda, Student
Lorraine Hamilton
Stephanie Howes, Volunteer
Lea-Anne Henry, Student
Melanie Hurlburt
Peter Koeller
Mark Lundy
Barry Macdonald
Bob Miller
Stephen Nolan
Doug Pezzack
Alan Reeves
Shawn Roach
Ginette Robert
Dale Roddick
Kent Russell, Volunteer
Kent Strychar, Volunteer
Bob Semple
Glyn Sharp
Stephen Smith
Koren Spence
Amy Thompson, Student
John Tremblay
Benedikte Vercaemer
Cathy Wentzell
Tana Worcester
Linda Worth-Bezanson

Centre for Marine Biodiversity:
Ellen Kenchington, Director
Victoria Clayton

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2003.
*Retired in 2003.

Marine Fish Division
Wayne Stobo, Manager
Diane Beanlands
Shelley Bond
Don Bowen
Bob Branton
Alida Bundy
Steve Campana
Peter Comeau
Paul Fanning
Wanda Farrell
Mark Fowler
Ralph Halliday*
Peter Hurley
Warren Joyce
Marjo Laurinolli
Bill MacEachern
Linda Marks
Meagan McCord, Student
Tara McIntyre
Jim McMillan
Jeff McRuer
Bob Mohn
Rachelle Noel
Jim Reid
Mark Showell
Jim Simon
Nancy Stobo
Scott Wilson
Gerry Young
Kees Zwanenburg

MFD Offsite:
Gilbert Donaldson
Jim Fennell
Emilia Williams

Ocean Sciences Division
Peter Smith, Manager
Gabriela Gruber
Meg Burhoe

Biological Oceanography:
Glen Harrison, Head
Jeffrey Anning
Florence Berreville, Student
Bilal Bjeirmi
Heather Bouman, Student
Jay Bugden
Benoit Casault
Carla Caverhill
Emmanuel Devred, PDF
Paul Dickie
Andrew Edwards, Research Associate
Marie-Hélène Forget, Student
Cesar Fuentes-Yaco, Research Associate
Leslie Harris
Erica Head
Edward Horne
Mary Kennedy
Paul Kepkay
Marilyn Landry
William Li
Alan Longhurst, Visiting Scientist
Svetlana Loza, Post Doctorate Fellow
Heidi Maass
Anitha Nair, Student
Markus Pahlow, Research Associate
Kevin Pauley
Linda Payzant
Trevor Platt
Catherine Porter
Douglas Sameoto
Jeffrey Spry
Alain Vézina
George White

Coastal Ocean Science:
Simon Prinsenberg, Head
Dave Brickman
Gary Bugden
Sandy Burtch
Jason Chaffey
Joël Chassé
Brendan DeTracey
Ken Drinkwater*
Ewa Dunlap
Frederic Dupont, PDF
Ken Frank
Dave Greenberg
Charles Hannah
Helen Hayden
Bob Lively
Ingrid Peterson
Brian Petrie
Liam Petrie
Roger Pettipas
Charles Tang
Chou Wang

Ocean Circulation:
John Loder, Head
Robert Anderson
Karen Atkinson
Kumiko Azetsu-Scott
Berit Babe, Visiting Scientist
Allyn Clarke
Sharon Gillam-Locke
Blair Greenan
Doug Gregory
Yijun He, Visiting Scientist
Ross Hendry
Jeff Jackson
Peter Jones
David Kellow
Zhenxia Long, Post Doctoral Fellow
Youyu Lu
Neil Oakey
Roberto Padilla-Hernandez, Visiting Scientist
William Perrie
Xuejuan Ren, Visiting Fellow
Marion Smith
Stuart Smith, Visiting Scientist
Brenda Topliss
Bash Toulany
Dan Wright
Igor Yashayaev
Frank Zemlyak
Weibiao Zhang, Visiting Scientist
Qingping Zou, Visiting Scientist

Ocean Physics:
Michel Mitchell, Head
Brian Beanlands
Larry Bellefontaine
Don Belliveau
Rick Boyce
Derek Brittain
Norman Cochrane
Katherine Collier*
John Conrod
Helen Dussault
George Fowler
Jim Hamilton
Bert Hartling
Alex Herman
Randy King
David McKeown*
Bruce Nickerson
Ted Phillips
Bob Ryan
Murray Scotney
George States
Scott Young

Marine Environmental Sciences Division
Paul Keizer, Manager
Jim Abriel
Byron Amirault
Debbie Anderson
Carol Anstey
Marie Archambault
Shelley Armsworthy
Ginnette Belbin
Robert Benjamin
Cynthia Bourbonnais
Chiu Chou
Pierre Clement

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2003.
*Retired in 2003.

Matthew Coady, Student
Susan Colvanli
Peter Cranford
Kristian Curran
John Dalziel
Jennifer Dixon
Lisa Doucette
Grazyna Folwarczna
Don Gordon
Gareth Harding
Barry Hargrave
Jocelyn Hellou
Rosalie Allen Jarvis
Thomas King
Brent Law
Ken Lee
Jim Leonard
Kevin MacIsaac
Paul MacPherson
Tim Milligan
John Moffatt
Pal Mortensen, PDF
Rick Nelson
Lisa Paon
Amanda Park
Georgina Phillips
Brian Robinson
Sheila Shellnut
Judy Simms
John Smith
Sean Steller
Peter Strain
Peter Thamer, Student
Herb Vandermeulen
Peter Vass
Gary Wohlgeschaffen
Philip Yeats

Maritimes Provinces Regional Advisory Process (RAP)/ Outreach
Bob O'Boyle, Coordinator
Steven Fancy, Student
Joni Henderson
Terry Myers, Student
Valerie Myra
Darcy O'Brien, Student

Species at Risk Coordination Office:
Jerry Conway
Lynn Cullen
Arran McPherson
Kirsten Querbach

Oceans and Environment Branch

Regional Director's office
Faith Scattolon, Regional Director
Carol Ann Rose, A/Regional Director
Shawna Bourque
Derek Fenton
Bev Grant

Habitat Management Division
Paul Boudreau, A/Manager
Stacey Burke
Joe Crocker
Rick Devine
Joy Dubé
André Ducharme
Kathy Godbout, Student
Joanne Gough
Anita Hamilton
Tony Henderson
Darren Hiltz
Brian Jollymore
Darria Langill
Jim Leadbetter
Melanie MacLean
Charlene Mathieu
Mark McLean
Shayne McQuaid
Ted Potter
Tammy Rose
Jim Ross*
Carol Sampson
Heidi Schaefer
Phil Seeto
Carol Simmons
Andrew Stewart
Reg Sweeney
Phil Zamora

Offsite (Gulf Fisheries Centre):
Ted Currie

Oceans and Coastal Management Division
Joe Arbour, Manager
Shauna Barrington, Student
Heather Breeze
Debi Campbell
Lesley Carter
Scott Coffen-Smout
Dave Duggan
Jennifer Hackett
Tim Hall
Glen Herbert
Stanley Johnston
Paul Macnab
Trevor Marchand, Volunteer
Denise McCullough
Melissa McDonald
Jason Naug
Celeine Renaud
Bob Rutherford*
Bob St-Laurent
Elizabeth Vardy, Intern
Maxine Westhead

Aquaculture Coordination Office

Mark Cusack, Director
Valerie Bradshaw
Darrell Harris
Cindy Webster
Sharon Young

Hypatia Project

Sherry Niven

Finance & Administration

Contract Services
Joan Hebert-Sellars

Material Services (Stores)
Larry MacDonald
Bob Page
Ray Rosse

Communications Branch

Carl Myers

Informatics

Technology Services
Gary Somerton, Chief
Chris Archibald
Eric Ashford
Keith Bennett
Paulette Bertrand
Patrice Boivin
Doug Brine
Mike Clarke
Kevin Dunphy
Bruce Fillmore
Judy Fredericks
Lori Gauthier

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2003.
*Retired in 2003.

Marc Hemphill
Jacqueline Leschied
Charles Mason
David McDonald
Jim Middleton
Dale Newell (Term)
Sue Paterson
Marie Salamé
Andrea Segovia
Mike Stepanczak
Paul Thom
Michael VanWageningen (Casual)
Charlene Williams
Paddy Wong

Client Services
Sandra Gallagher, Chief
Bonnie Fillmore
Pamela Gardner
Ron Girard
Carol Levac
Juanita Pooley
Kevin Ritter

Application Services Division
Jim Gale, Head
Lenore Bajona
Florence Hum
Anthony Joyce
Peter Monaghan
Kohila Thana

Special Projects Division
John O'Neill, A/Manager
Tobias Spears, Head
Blair David
Adrian Inness

Library
Anna Fiander, Chief
Rhonda Coll
Lori Collins
Lois Loewen
Maureen Martin
Tim McIntyre
Marilynn Rudi
Diane Stewart

Records
Jim Martell, Supervisor
Myrtle Barkhouse
Brenda Brown

NATURAL RESOURCES CANADA

Geological Survey Of Canada (Atlantic)

Director's Office
Jacob Verhoef, Director
Jennifer Bates
Pat Dennis
Carmelita Fisher
Don McAlpine
Judith Ryan

Administration
George McCormack, Manager
Cheryl Boyd
Dianne Burns
Terry Hayes
Cecilia Middleton
Barb Vetese

Marine Resources Geoscience
Mark Williamson, Manager
Mike Avery
Ross Boutilier
Bob Courtney
Bernie Crilley
Claudia Currie
Sonya Dehler
Rob Fensome
Peter Giles
Paul Girouard
Gary Grant
Ken Hale
Evelyn Inglis
Arthur Jackson
Ruth Jackson
Chris Jauer
Nelly Koziel
Paul Lake
Bill MacMillan
Anne Mazerall
Phil Moir
Gordon Oakey
Phil O'Regan
Russell Parrott
Stephen Perry
Patrick Potter
Wayne Prime
Matt Salisbury
John Shimeld
Phil Spencer
Barbe Szlavko
Frank Thomas
Hans Wielens
Graham Williams
Marie-Claude Williamson

Marine Environmental Geoscience
Dick Pickrill, Manager
Ken Asprey
Anthony Atkinson
David Atkinson
Marie Baker
Darrell Beaver
Steve Blasco
Austin Boyce
Owen Brown
Calvin Campbell
Borden Chapman
Lori Cook
Jaime Dawson
Gordon Fader
Robert Fitzgerald
Donald Forbes
David Frobel
Iris Hardy
Robert Harmes
David Heffler
Sheila Hynes
Kate Jarrett
Kimberley Jenner
Fred Jodrey
Heiner Josenhans
Edward King
Vladimir Kostylev
Bill LeBlanc
Michael Li
Tracey Lynds
Maureen MacDonald
Kevin MacKillop
Bill MacKinnon
Gavin Manson
Susan Merchant
Bob Miller
David Mosher
Bob Murphy
Kathyrn Parlee
Michael Parsons
David Piper
Angus Robertson
Andre Rochon
John Shaw
Andy Sherin
Carolyn Smyth
Steve Solomon
Gary Sonnichsen
Bob Taylor
Brian Todd
Bruce Wile

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2003.
*Retired in 2003.

PUBLIC WORKS AND GOVERNMENT SERVICES

Leo Lohnes, Property Manager
Diane Andrews
Bob Cameron
Geoff Gritten
Paul Fraser
Jim Frost
Garry MacNeill
Paul Miles
Richard Netherton
Fred Rahey
Phil Williams
Bill Wood

NATIONAL RESEARCH COUNCIL CANADA

Don Douglas

COMMISSIONAIRES

William Bewsher
Paul Bergeron
Dave Cyr
John Dunlop
Donnie Hotte
Rex Lane
Leonard MonMinie
Francis Noonan
Don Smith
Lester Tracey

CAFETERIA STAFF

Kelly Bezanson
Randy Dickson
Lynn Doubleday
Tammy Heisler
Mark Vickers

OTHERS ON THE BIO CAMPUS

International Ocean Colour Coordinating Group (IOCCG)

Venetia Stuart, Executive Scientist
Tammy Chouinard

Partnership for the Observation of the Global Oceans (POGO)

Shubha Sathyendranath, Executive Director
Tony Payzant

Fishermen and Scientists Research Society (FSRS)

Jeff Graves
Carl MacDonald
Shannon Scott-Tibbetts

Geoforce Consultants Ltd.

Mike Belliveau
Graham Standen
Martin Uyesugi

Contractors

Mark Adams, Marine Fish
Michael Botek, Biological Oceanography
Heather Breeze, OCMD
Pierre Brien, Informatics: Special Projects Division
Derek Broughton, Marine Fish
Catherine Budgell, Library
Barbara Corbin, Records
Roch Daneau, Informatics: Special Projects Division
Tania Davignon-Burton, Marine Fish
Kevin Desroches, CHS
Adam Drozdowski, Coastal Ocean Science
Mike Friis, Records*
Bob Gershey, Ocean Circulation
Yuri Geshelin, Ocean Circulation
Steven Grant, CHS
Ian Hamilton (CHS)
Adam Hanway, CHS
Matt Hawley, CHS
Karen Hiltz, MESD
Yongcun Hu, Ocean Circulation
Raouf Kilada, IFD
Edward Kimball, Ocean Circulation
Weibiao Li, Ocean Circulation
Alexander MacLean, Informatics: Special Projects Division
Louise Malloch, Biological Oceanography
Kathryn Mombourquette, IFD
Jill Moore, Marine Fish
Lene Mortensen, MIDI
Kee Muschenheim, MESD
Peter Payzant, Biological Oceanography
Tim Perry, Biological Oceanography
Merle Pittman, Ocean Physics
Jeff Potvin, Informatics
Edith Rochon, Library
Sylvie Roy, MESD
Heidi Schaefer, OCMD
Christian Solomon, CHS
Victor Soukhovtsev, Coastal Ocean Science
Jacquelyn Spry, Biological Oceanography
David Trudel, CHS
Tineke van der Baaren, Coastal Ocean Science
Tammy Waetcher, CHS
Donovan Westhaver, CHS
Susan White, Ocean Physics
Wesley White, Diadromous Fish
Arthur Wickens, CHS
Alicia Williams, Marine Fish
Inna Yashayaeva, Ocean Circulation
Baoshu Yin, Ocean Circulation

Scientist Emeritus

Piero Ascoli
Dale Buckley
Ray Cranston
Lloyd Dickie
Fred Dobson
Subba Rao Durvasula
Jim Elliott
Ken Freeman
Alan Grant
Peter Hacquebard
Lubomir Jansa
Brian Jessop
Charlotte Keen
Tim Lambert
Don Lawrence
John Lazier
Mike Lewis
Doug Loring
Brian MacLean
Ron Macnab
Ken Mann
Clive Mason
Peta Mudie
Charlie Quon
Charlie Ross
Hal Sandstrom
Charles Schafer
Shiri Srivastava
James Stewart
John Wade

Recognition

BIO staff wish to recognize the contribution and support provided by the Captains and crew of Canadian Coast Guard vessels tasked to assist BIO-based research.

INDIVIDUALS WHO RETIRED IN 2003

Katherine Collier retired from the Ocean Sciences Division in March 2003 after 35 years of outstanding service. Katherine began her career as a casual employee with Personnel Branch at BIO in 1968, moved to Policy and Planning Branch in 1971, and to the Department of Supply and Services in 1973. She began providing administrative services to scientific staff in 1977 when she returned to BIO and joined the Metrology Division of the Atlantic Oceanographic Laboratory. The unsurpassed accuracy of her work and records was a source of pride to Katherine and a major asset to her managers. Colleagues also routinely relied on her experience and in-depth knowledge of policies and procedures for valuable advice. She will be missed.

Ken Drinkwater retired in January 2003 after 30 years of distinguished service as a physical oceanographer in the Marine Ecology Laboratory (MEL), the Atlantic Oceanographic Laboratory, and finally the Ocean Sciences Division of DFO. His early years in MEL focused on the interaction of ocean climate and fisheries, a theme that prevailed throughout his career. Along with Ron Trites, his long-time collaborator and mentor, he was physical oceanography's main link to the biological-fisheries world. Ken also represented DFO internationally, in particular contributing to the Northwest Atlantic Fisheries Organization for more than 20 years. In fact, he has retired only from DFO; Ken has taken up a new position with Havforskningsinstituttet (Institute of Marine Research) in Bergen, Norway where he will continue to pursue climate-fisheries studies. He will maintain a link to BIO through a joint project in Davis Strait.

Mike Friis was an employee of DASC (Dartmouth Adult Services Centre) Industries from 1969 until 2003. He was involved with DASC when it began as a craft-based recreation program for individuals with intellectual disabilities. As a participant in DASC's community employment program, Mike enjoyed working for 25 years at BIO as a mail messenger in the Records Office, where he was a conscientious team worker who took great pride in his work. His duties included sorting incoming and outgoing mail, delivering courier packages, and making three mail runs every day. Throughout BIO he was warmly regarded for his efficiency and good humour. On December 19, Mike celebrated his retirement at a party with BIO staff. Since then, he is enjoying spending time with his family and working on crafts. His presence at BIO, and indeed DASC, will not soon be forgotten. Thank you, Mike, for the opportunity to know you.

Ralph Halliday retired from the Marine Fish Division (MFD) in January after 35 years with DFO. Throughout his career, Ralph was consistent and enthusiastic in his belief in the importance of active participation by the science community in the management of fisheries. He began as a Post Doctoral Fellow at the St. Andrew's Biological Station in 1966. He established the bottom trawl survey program in 1970, now a central element of ecosystem monitoring, and was head of the Population Dynamics Section at St. Andrew's during the early ecosystem monitoring and early development of stock assessment. Highly respected within the international stock assessment community, Ralph was a senior Canadian advisor at international negotiations on fish stock conservation measures. As the first Manager of the MFD, which was created in 1976 on the extension of fisheries jurisdiction, he developed the vision, recruited the staff, and implemented the program to meet the Division's greatly expanded responsibility. In 1981, he took a two-year leave from MFD to become the first full-time Chairman of the Canadian Atlantic Fisheries Scientific Advisory Committee, returning to DFO as a scientist to pursue his research interests on fisheries management issues. For several years he was Chairman of the regional Fisheries Management Studies working group and was a major contributor to the development of Objective Based Fisheries Management in the region. Ralph has chosen to continue his association with DFO as an emeritus scientist.

Malcolm Jay retired from the Canadian Hydrographic Service (CHS) after 35 years of public service. Jay worked in Pictou for a short time as a General Seaman on the Baffin before going to Ottawa where he worked for the city's planning division, then for Indian and Northern Affairs Canada (as it is known today). Jay was hired by CHS Headquarters as a Cartographer in 1977, and transferred to the Atlantic Region in the Spring of 1978. He continued as a Cartographer at BIO and enrolled in the multi-disciplinary hydrographer program, and until his retirement he conducted digital quality control for the preparation of files for the S-57 ENC project. On March 29, at a successful retirement party, many colleagues and CHS retirees joined Jay in the celebration.

Roger Jones retired in March from the CHS after 37 years of service. Roger was hired by Headquarters Region as a Cartographer in 1967. Ten years later he moved from Ottawa to the Maritimes Region, where he has worked as a Cartographer ever since. Before retiring, he became the Nautical Publications Quality Control Specialist. Product standards are always evolving and Roger was responsible for paper products and also for newer ENC product lines. He is an avid fisher and carpenter/craftsman. He is now working on a number of "decks" for his new clients. Roger's retirement party was a great success, and we were very pleased to see a number of CHS retirees in attendance.

David McKeown retired in October after 35 years of devoted service to science at DFO. Dave dedicated his career to developing instrumentation and applying technology to address program needs, both as a research scientist and as Head of the Metrology Division. He later took on the leadership of the Technical Operations Section of the Ocean Sciences Division and continued to ensure BIO maintained an efficient sea-going capability. He served on and led numerous regional and national committees to represent the operational needs of the BIO science community. In particular, his efforts through the Science Vessel Users and other committees have truly benefited BIO. Dave is now an emeritus scientist and continues his latest collaborative work with colleagues in Habitat Ecology.

William Preston retired on May 31. Bill worked for several years as an engine room assistant on Canadian Coast Guard vessels. In the late 1980s, he came ashore to work

within the yard maintenance group at the Dartmouth Canadian Coast Guard Base, where he was involved in the maintenance of floating aids (buoys). He acquired his mobile crane operator's certificate, which allowed him to carry out the duties of yard crane operator at the Dartmouth Base. In the mid-1990s, Bill moved from the Dartmouth Canadian Coast Guard Base, to the Bedford Institute of Oceanography, where he assumed the duties of the mobile crane operator/maintainer in support of the science community at the Institute.

James Ross joined the CHS as a student in 1972. After successfully performing many roles within CHS, in 1992 Jim left to participate in the Public Service Canada Management Training Program. Jim joined the DFO Habitat program in the mid-1990s, playing a key role in the development and implementation of the program as Section Head at BIO. In that role he showed his keen interest in the environment, and its protection. Day-to-day supervision of staff was a benefit and pleasure to both supervised and supervisor. Jim also played an important role in developing a national approach to the management of aquaculture. Based on his experience with this evolving sector, he was responsible for some key joint Habitat Management/Environmental Science initiatives. During a one-year assignment in National Headquarters, Jim led a national working group on aquaculture to develop guidance material which contributed to a more coherent approach to the environmental management of this challenging industrial sector. Jim retired from DFO in May. In addition to his many extracurricular activities that include travel and physical fitness, he has turned his talents to teaching a course in water resource management for the Nova Scotia Community College. His colleagues, both within and outside DFO, will miss his commitment, vision, and healthy attitude to life.

Robert Rutherford joined DFO in 1973. Bob's longstanding commitment to the Department included fish passage studies; fish habitat assessments; habitat protection guidelines; best management techniques, education, and awareness with the forestry, aquaculture, and urban development sectors; and freshwater and coastal habitat restoration. With this background, he moved on to managing the Fish Habitat Section of the Green Plan initiative, and then to the *Oceans Act* programs. Since the early 1990s, Bob has been instrumental in the delivery of oceans and coastal management projects and programs. His leadership in coastal resource mapping resulted in the development of a valuable tool now widely used by coastal communities and government agencies. He was also among the vanguard that outlined the policies and developed the internal mechanisms that turned the 1997 *Oceans Act* into reality. In 1998, he served as point man for the Eastern Scotian Shelf Integrated Management Initiative, perhaps DFO's highest profile and most advanced integrated management effort. He has long established working relationships with First Nations organizations, notably in the Bras d'Or Lakes area. Most recently, as a member of the national working group, Bob helped draft the regulations for the design and establishment of The Gully and Musquash Estuary Marine Protected Areas, which will serve as a lasting testament to Bob's leadership and commitment to DFO. He retired in June of 2003 and continues to work with community groups on watershed and coastal management planning and aquatic habitat rehabilitation. Many people, both within DFO and outside, will miss his wisdom, patience, and exceptional drive.

Heinz Wiele's career at BIO began in 1970 as the third employee in the small Photography Unit. Early in his career Heinz operated the cartographic camera, which was used for navigation charts, electronic printed circuits reduction, and copy work. Much of the work Heinz did on the large camera would years later be done on computers. In the 1970s, Heinz went to sea to operate underwater cameras, and for the next three decades was instrumental in the acquisition of high quality underwater images for DFO and NRCan. To meet the scientists' requests, Heinz spent a lot of his career in the field. The field included labs, helicopters, small boats, large ships, or on the shoreline. From macro to aerial photography, scientific photography at BIO can be very challenging; Heinz always came up with creative and interesting solutions that produced quality photographs. Before retiring in 2003, Heinz set up the digital archiving system for images taken by the photo unit. This digital archive is the data bank for all existing and future images shot by the BIO Photo Unit.

Publications and Products

Publications 2003

FISHERIES AND OCEANS CANADA

Maritimes Region - Science Branch - Bedford Institute of Oceanography

1) Biological Sciences:

Recognized Scientific Journals:

Austin, D., J.I. McMillan, and W.D. Bowen. 2003. A three-stage algorithm for correcting ARGOS satellite locations. Mar. Mamm. Sci. 19: 371-383.

Beck, C.A., W.D. Bowen, and S.J. Iverson. 2003. Seasonal energy storage and expenditure in a phocid seal: Evidence of sex-specific trade-offs. J. Anim. Ecol. 72: 280-291.

Beck, C.A., W.D. Bowen, J.I. McMillan, and S.J. Iverson. 2003. Sex differences in diving at multiple temporal scales in a size-dimorphic capital breeder. J. Anim. Ecol. 72: 979-993.

Beck, C.A., W.D. Bowen, J.I. McMillan, and S.J. Iverson. 2003. Sex differences in the diving behaviour of a size dimorphic capital breeder: The grey seal. Anim. Behav. 66: 777-789.

Bowen, W.D., J. McMillan, and R. Mohn. 2003. Sustained exponential population growth of grey seals on Sable Island, Nova Scotia. ICES J. Mar. Sci. 60: 1265-1274.

Bowen, W.D., S.L. Ellis, S.J. Iverson, and D.J. Boness. 2003. Maternal and newborn life-history traits during periods of contrasting population trends: Implications for explaining the decline of harbour seals, *Phoca vitulina*, on Sable Island. J. Zool. (Lond.) 261: 155-163.

Campana, S.E., R.D. Stanley, and S. Wischniowski. 2003. Suitability of glycerin-preserved otoliths for age validation using bomb radiocarbon. J. Fish Biol. 63: 848-854.

Claytor, R.R., and J. Allard. 2003. Change-in-ratio estimates of lobster exploitation rate using sampling concurrent with fishing. Can. J. Fish. Aquat. Sci. 60: 1190-1203.

Comeau, L.A., and S.E. Campana. 2003. Modifying thyroidal status in Atlantic cod by osmotic pump delivery of thryoid and antithyroid agents. Trans. Am. Fish. Soc. 132: 1021-1026.

Comeau, L.A., S.E. Campana, and M. Castonguay. 2003. Automated monitoring of a large-scale cod (*Gadus morhua*) migration in the open sea. Can. J. Fish. Aquat. Sci. 59: 1845-1850.

Dwyer, K.S., S.J. Walsh, and S.E. Campana. 2003. Age determination, validation and growth of Grand Bank yellowtail flounder (*Limanda ferruginea*). ICES J. Mar. Sci. 60: 1123-1138.

Gibson, A.J.F., and R.A. Myers. 2003. A meta-analysis of the habitat carrying capacity and the maximum lifetime reproductive rate of anadromous alewife in eastern North America, p. 211-221. *In* K.E. Limburg and J.R. Waldman [ed.]. Biodiversity, Status, and Conservation of the World's Shads. Am. Fish. Soc. Symp. 35, Bethesda, Maryland.

Gibson, A.J.F., and R.A. Myers. 2003. A statistical, age-structured, life history based stock assessment model for anadromous *Alosa*, p. 275-283. *In* K.E. Limburg and J.R. Waldman [ed.]. Biodiversity, Status, and Conservation of the World's Shads. Am. Fish. Soc. Symp. 35, Bethesda, Maryland.

Henry, L.-A., E.L.R. Kenchington, and A. Silvaggio. 2003. Effects of experimental disturbance on aspects of colony behaviour, reproduction and regeneration in the cold water octocoral *Gersemia rubiformis* (Ehrenberg, 1834). Can. J. Zool. 81: 1691-1701.

Jessop, B.M. 2003. Annual and seasonal variability in the size and biological characteristics of the runs of American eel elvers to two Nova Scotia rivers, p. 17-36. *In* D. Dixon [ed.]. Biology, Management, and Protection of Catadromous Eels. Am. Fish. Soc. Symp. 33, Bethesda, Maryland.

Jessop, B.M. 2003. Annual variability in the effects of water temperature, discharge, and tidal stage on the migration of American eel elvers from estuary to river, p. 3-16. *In* D. Dixon [ed.]. Biology, Management, and Protection of Catadromous Eels. Am. Fish. Soc. Symp. 33, Bethesda, Maryland.

Jessop, B.M. 2003. The effects of exploitation on Alewife and Blueback herring stock composition at the Mactaquac Dam, Saint John River, New Brunswick, p. 349-359. *In* K.E. Limburg and J.R. Waldman [ed.]. Biodiversity, Status, and Conservation of the World's Shads. Am. Fish. Soc. Symp. 35, Bethesda, Maryland.

Jones, M.W., P.T. O'Reilly, A.A. McPherson, T.L. McParland, D.E. Armstrong, A.J. Cox, K.R. Spence, E.L. Kenchington, C.T. Taggart, and P. Bentzen. 2003. Development, characterisation, inheritance and cross-species utility of American lobster (*Homarus americanus*) microsatellite and mtDNA PCR-RFLP markers. Genome 46: 59-69.

Kenchington, E., C.J. Bird, J. Osborne, and M. Reith. 2002.* Novel repeat elements in the nuclear ribosomal RNA operon of the flat oysters *Ostrea edulis* C. Linnaeus, 1758 and *O. angasi* Sowerby, 1871. J. Shellfish Res. 21: 697-705.

Kenchington, E., M. Heino, and E.E. Nielsen. 2003. Managing marine genetic diversity: Time for action? ICES J. Mar. Sci. 60: 1172-1176.

Koeller, P. 2003. The lighter side of reference points. Fish. Res. 62: 1-6.

Koeller, P.A., M. Covey, and M. King. 2003. Is size at sex transition an indicator of growth or abundance in pandalid shrimp? Fish. Res. 65: 217-230.

* Citation year is 2002; however, publication occurred after publication of Bedford Institute of Oceanography 2002 in Review.

Kulka, D.W., D.E. Themelis, and R.G. Halliday. 2003. Orange roughy (*Hoplostethus atlanticus* Collett 1889) in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. 31: 47-56.

Lidgard, D.C., D.J. Boness, W.D. Bowen, and J.I. McMillan. 2003. Diving behaviour during the breeding season in the terrestrial breeding male grey seal: Implications for alternative mating tactics. Can. J. Zool. 81: 1025-1033.

MacNeil, M.A., and S.E. Campana. 2003. Comparison of whole and sectioned vertebrae for determining the age of young blue shark (*Prionace glauca*). J. Northw. Atl. Fish. Sci. 30: 77-82.

McIntyre, T.M., and J.A. Hutchings. 2003. Small-scale temporal and spatial variation in Atlantic cod (*Gadus morhua*) life history. Can. J. Fish. Aquat. Sci. 60: 1111-1121.

McPherson, A.A., R.L. Stephenson, and C.T. Taggart. 2003. Genetically different Atlantic herring *Clupea harengus* spawning waves. Mar. Ecol. Prog. Ser. 247: 303-309.

Miller, R.J. 2003. Be-all-you-can-be management targets for Canadian lobster fisheries. Fish. Res. 64: 179-184.

Mueirert, M.M.C., W.D. Bowen, and S.J. Iverson. 2003. Weaning mass affects changes in body composition and food intake in harbour seal pups during the first month of independence. Physiol. Biochem. Zool. 76: 418-427.

Schmidt, R.E., B.M. Jessop, and J.E. Hightower. 2003. Status of river herring stocks in large rivers, p. 171-182. *In* K.E. Limburg and J.R. Waldman [ed.]. Biodiversity, Status, and Conservation of the World's Shads. Am. Fish. Soc. Symp. 35, Bethesda, Maryland.

Smith, S.J., and M.J. Tremblay. 2003. Fishery-independent trap surveys of lobsters (*Homarus americanus*): Design considerations. Fish. Res. 62: 65-75.

Smith, S.J., Z. Lucas, and W.T. Stobo. 2003. Population estimate of Ipswich sparrows on Sable Island, Nova Scotia in 1998 using a random transect survey design. Can. J. Zool. 81: 771-779.

Swain, D.P., A.F. Sinclair, M. Castonguay, G.A. Chouinard, K.F. Drinkwater, L.P. Fanning, and D.S. Clark. 2003. Density-versus temperature-dependent growth of Atlantic cod (*Gadus morhua*) in the Gulf of St. Lawrence and on the Scotian Shelf. Fish. Res. 59: 327-341.

Departmental Reports:

Amiro, P.G. 2003. Population status of inner Bay of Fundy Atlantic salmon (*Salmo salar*), to 1999. Can. Tech. Rep. Fish. Aquat. Sci. 2488. vi + 44 p.

Freeman, K.R., and R.E. Lavoie. 2003. Winter storage of the American oyster (*Crassostrea virginica*) in Cape Breton, Nova Scotia. Can. Manuscr. Rep. Fish. Aquat. Sci. 2652: iv + 9 p.

Gibson, A.J.F., J. Bryan, and P. Amiro. 2003. Release of hatchery-reared Atlantic salmon into Inner Bay of Fundy rivers from 1900 to 2002. Can. Data Rep. Fish. Aquat. Sci. 1123. vi + 28 p.

Gibson, A.J.F., and R.A. Myers. 2003. Biological reference points for anadromous alewife (*Alosa pseudoharengus*) fisheries in the Maritime Provinces. Can. Tech. Rep. Fish. Aquat. Sci. 2468. vi + 50 p.

Henry, L., E. Kenchington, D.C. Gordon, Jr., K. MacIsaac, and C. Bourbonnais. 2002.* Indicators of benthic biodiversity for the eastern Scotian Shelf. Can. Tech. Rep. Fish. Aquat. Sci. 2433: ix + 61 p.

Jackson, D.L, B.W. MacDonald, B.Vercaemer, X. Guo, A. Mallet, and E. Kenchington. 2003. Investigations with triploid Atlantic Sea Scallops, *Placopecten magellanicus*, at the Bedford Institute of Oceanography, 2000-2003. Can. Tech. Rep. Fish. Aquat. Sci. 2460: v + 48 p.

Jessop, B.M. 2003. The run size and biological characteristics of American eel elvers in the East River, Chester, Nova Scotia, 2000. Can. Tech. Rep. Fish. Aquat. Sci. 2444. iv + 42 p.

Jessop, B.M., and C.J. Harvie. 2003. A CUSUM analysis of discharge patterns by a hydroelectric dam and discussion of potential effects on the upstream migration of American eel elvers. Can. Tech. Rep. Fish. Aquat. Sci. 2454 v + 28 p.

Moore, J.A., G. Robert, and R.E. Lavoie. 2003. Clam resource enhancement in Chezzetcook Harbour, Nova Scotia: A comparative growth study (project update). Can. Ind. Rep. Fish. Aquat. Sci. 268: v + 15 p.

Randall, R.G., R.E. Allen, E.M.P. Chadwick, R.R. Claytor, and J. Helbig. 2003. National Science Workshop 2002, Fisheries and Oceans Canada, Burlington, Ontario / Alelier national des sciences 2002, Pêches et Océans Canada, Burlington (Ontario). Can. Tech. Rep. Fish. Aquat. Sci. / Rapp. tech. can. sci. halieut. aquat. 2463. 234 p.

Sharp, G., R. Semple, K. Connolly, R. Blok, D. Audet, D. Cairns, and S. Courtenay. 2003. Ecological assessment of the Basin Head Lagoon: A proposed Marine Protected Area. Can. Manuscr. Rep. Fish. Aquat. Sci. 2641: vi + 70 p.

Smith, S.J. [ed.]. 2003. Workshop on biological reference points for invertebrate fisheries held in Halifax, Nova Scotia, 2-5 December, 2002: Abstracts and Proceedings. Can. Tech. Rep. Fish. Aquat. Sci. 2448: ix + 62 p.

Tremblay, M.J., Y. Andrade, and R.K. O'Dor. 2003. Small-scale movements of lobsters (*Homarus Americanus*): An application of radio-acoustic positioning and telemetry (rapt) with an analysis of system resolution. Can. Tech. Rep. Fish. Aquat. Sci. 2439: iv + 19 p.

Vercaemer, B., K. Spence, E. Kenchington, A. Mallet, and J. Hardin . 2003. Assessment of genetic diversity of the European oyster (*Ostrea edulis*) in Nova Scotia using microsatellite markers. Can. Tech. Rep. Fish. Aquat. Sci. 2453: v + 30 p.

Special Publications:

Amiro, P.G., J. Gibson, and K. Drinkwater. 2003. Identification and exploration of some methods for designation of critical habitat for survival and recovery of inner Bay of Fundy Atlantic salmon (*Salmo salar*). DFO Can. Sci. Advis. Sec. Res. Doc. 2003/120. 27 p.

Campana, S., W. Joyce, and L. Marks. 2003. Status of the porbeagle shark (*Lamna nasus*) population in the northwest Atlantic in the context of species at risk. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/007. 27 p.

DFO. 2003. 2001 state of the ocean: physical oceanographic conditions on the Scotian Shelf, Bay of Fundy and Gulf of Maine. DFO Sci., Ecosys. Status Rep. 2003/002. 9 p.

DFO. 2003. 4VWX herring. DFO Sci., Stock Status Rep. 2003/027. 12 p.

DFO. 2003. American plaice in the Southern Gulf of St. Lawrence (Div. 4T). DFO Sci., Stock Status Rep. 2003/004. 4 p.

DFO. 2003. Atlantic herring: Georges Bank, Nantucket Shoals, Gulf of Maine Stock Complex. DFO Sci., Stock Status Rep. 2003/028. 7 p.

DFO. 2003. Atlantic salmon Maritime Provinces overview for 2002. DFO Sci., Stock Status Rep. 2003/026. 46 p.

DFO. 2003. Cod in the Southern Gulf of St. Lawrence. DFO Sci., Stock Status Rep. 2003/016. 9 p.

DFO. 2003. Eastern Georges Bank cod. DFO Sci., Stock Status Rep. 2003/040. 6 p.

DFO. 2003. Eastern Georges Bank haddock. DFO Sci., Stock Status Rep. 2003/041. 6 p.

DFO. 2003. Eastern Nova Scotia snow crab. DFO Sci., Stock Status Rep. 2003/029. 11 p.

DFO. 2003. Georges Bank scallop. DFO Sci., Stock Status Rep. 2003/038. 11 p.

DFO. 2003. Georges Bank yellowtail flounder. DFO Sci., Stock Status Rep. 2003/042. 6 p.

DFO. 2003. Scallop Production Areas (SPAs) in the Bay of Fundy. DFO Sci., Stock Status Rep. 2003/025. 25 p.

DFO. 2003. Southern Gulf of St. Lawrence (4T) herring. DFO Sci., Stock Status Rep. 2003/035. 9 p.

DFO. 2003. Southern Gulf of St. Lawrence snow crab (Areas 12, E and F). DFO Sci., Stock Status Rep. 2003/019. 16 p.

DFO. 2003. Southwestern Nova Scotia snow crab. DFO Sci., Stock Status Rep. 2003/030. 7 p.

DFO. 2003. State of the Eastern Scotian Shelf Ecosystem. DFO Sci., Ecosys. Status Rep. 2003/004. 25 p.

DFO. 2003. Western Cape Breton snow crab (Area 18). DFO Sci., Stock Status Rep. 2003/033. 12 p.

DFO. 2003. Western Cape Breton snow crab (Area 19). DFO Sci., Stock Status Rep. 2003/034. 12 p.

DFO. 2003. White hake in the Southern Gulf of St. Lawrence (Div. 4T). DFO Sci., Stock Status Rep. 2003/001. 5 p.

DFO. 2003. Winter flounder in the Southern Gulf of St. Lawrence (Div. 4T). DFO Sci., Stock Status Rep. 2003/003. 5 p.

DFO. 2003. Witch flounder (Divs. 4RST). DFO Sci., Stock Status Rep. 2003/005. 7 p.

DFO. 2003. Yellowtail flounder in the Southern Gulf of St. Lawrence. DFO Sci., Stock Status Rep. 2003/002. 5 p.

Fanning, L.P., R.K. Mohn, and W.J. MacEachern. 2003. Assessment of 4VsW cod to 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/027. 41 p.

Geddes, D.E. [ed.]. 2003. Bedford Institute of Oceanography - 2002 in review. Fisheries and Oceans Canada and Natural Resources Canada. 108 p.

Gibson, A.J.F., and P.G. Amiro. 2003. Abundance of Atlantic salmon (*Salmo salar*) in the Stewiacke River, N.S., from 1965 to 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/108. 38 p.

Gibson, A.J.F., P.G. Amiro, and K.A. Robichaud-LeBlanc. 2003. Densities of juvenile Atlantic salmon (*Salmo salar*) in inner Bay of Fundy rivers during 2000 and 2002 with reference to past abundance inferred from catch statistics and electrofishing surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/121. 63 p.

Gibson, A.J.F., R. Jones, P.G. Amiro, and J.J. Flanagan. 2003. Abundance of Atlantic salmon (*Salmo salar*) in the Big Salmon River, N.B., from 1951 to 2002. DFO Can. Sci. Advis. Sec. Res. Doc 2003/119. 55 p.

Koeller, P.A., M. Covey, and M. King. 2003. Assessment of the Eastern Scotian Shelf shrimp stock and fishery for 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/005. 49 p.

Lavoie, R.E. 2003. Proceedings of the Maritime Regional Advisory Process on the Bay of Fundy scallop and Scallop Fishing Area 29; 22-23 January, 2003. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/038. vi + 18 p.

Lavoie, R.E. 2003. Proceedings of the Maritime Regional Advisory Process on the Eastern Scotian Shelf snow crab; 26-27 February, 2003. DFO Can Sci. Advis. Sec. Proceed. Ser. 2003/039. vi + 42 p.

Marshall, T.M., G. Stevens, and K. Rutherford. 2003. Proceedings of a workshop to develop guidelines for support of Southern Upland N.S. and Eastern Cape Breton Island Atlantic salmon. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/006. 79 p.

Neilson, J., P. Perley, E. H. Carruthers, W. Stobo, and D. Clark. 2003. Stock structure of pollock in NAFO Divs. 4VWX5Zc. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/045. 53 p.

O'Boyle, R. 2003. Meeting on the assessment framework for 4T herring; 18-19 March 2002. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/009. v + 23 p.

O'Boyle, R. 2003. Proceedings of the fifth meeting of the Transboundary Resources Assessment Committee. TAW'G Meeting; 23-25 April 2003. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/007. v + 21 p.

O'Boyle, R. 2003. Proceedings of the Maritimes RAP meeting on assessment frameworks and decision rules for 4X-5Y cod and haddock. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/008. vi + 67 p.

O'Boyle, R., and P. Keizer. 2003. Proceedings of three workshops to investigate the unpacking process in support of ecosystem-based management; February-July 2002. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2003/004. v + 31 p.

Simon, J.E., L. Harris, and T. Johnston. 2003. Distribution and abundance of winter skate, *Leucoraja ocellatta*, in the Canadian Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/028. 67 p.

Smith, S.J. 2003. Proceedings of the Maritimes Regional Advisory Process on the Georges Bank Scallop Stock; 24 June 2003. Can. Sci. Advis. Sec. Proceed. Ser. 2003/036. 15 p.

Smith, S.J., M.J. Lundy, D. Roddick, D. Pezzack, and C. Frail. 2003. Scallop Production Areas in the Bay of Fundy and Scallop Fishing Area 29 in 2002: Stock status and forecast. Can. Sci. Advis. Sec. Res. Doc. 2003/010. 103 p.

Zwanenburg, K., S. Wilson, R. Branton, and P. Brien. 2003. Halibut on the Scotian Shelf and southern Grand Banks – current estimates of population status. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/046. 33 p.

Books; Book Chapters:

Kenchington, E. 2003. The effects of fishing on species and genetic diversity, p. 235-253. *In* M. Sinclair and G. Valdimarsson [ed.]. Responsible Fisheries in the Marine Ecosystem. CAB International, Wallingford, Oxon, UK. 448 p.

Sinclair, M., and Valdimarsson, G. [ed]. 2003. Responsible fisheries in the marine ecosystem. Food and Agriculture Organization of the United Nations/Cabi Publishing, Oxon, UK. 426 p.

2) Canadian Hydrographic Service:

Recognized Scientific Journals:

Varma, H., K. Fadaie, and M. Habbane. 2003. Confusion in data fusion. Int. J. Remote Sens. 24(4): 90-110.

Special Publications:

Webster, T., S. Dickie, C. O'Reilly, D. Forbes, G. Parkes, D. Poole, and R. Quinn. 2003. Mapping storm surge flood risk using a LIDAR-derived DEM. GeoSpatial Solutions, May 2003 edition.

Conference Proceedings:

O'Reilly, C.T., D.L. Forbes, and G.S. Parkes. 2003. Mitigation of coastal hazards: Adaptation to rising sea levels, storm surges, and shoreline erosion, p. 1-10. *In* Proceedings, 2003 Annual Conference, Canadian Society for Civil Engineering, Moncton, June 4-7, 2003.

3) Marine Environmental Sciences:

Recognized Scientific Journals:

Beauchamp, S., R. Tordon, L. Phiney, K. Abraham, A. Pinette, A. MacIntosh, A. Rencz, H. Wong, and J. Dalziel. 2002.* Air-surface exchange of mercury in natural and anthropogenically impacted landscapes in Atlantic Canada. Geochem. Explor. Environ. Anal. 2: 157-165.

Chou, C.L., K. Haya, L.A. Paon, and J.D. Moffatt. 2003. Metals in the green sea urchin (*Strongylocentrotus droebrachiensis*) as an indicator for the near-field effects of chemical wastes from salmon aquaculture sites in New Brunswick, Canada. Bull. Environ. Contam. Toxicol. 70: 948-956.

Chou, C.L., L.A. Paon, J.D. Moffatt, and T. King. 2003. Selection of bioindicators for monitoring marine environmental quality in the Bay of Fundy, Atlantic Canada. Mar. Pollut. Bull. 46: 756-762.

Chou, C.L., L.A. Paon, J.D. Moffatt, and B. Zwicker. 2003. Bioaccumulation and interrelationship of manganese and zinc in horse mussel *Modiolus modiolus* from Eastern Canada. Fish. Sci. 69: 369-378.

* Citation year is 2002; however, publication occurred after publication of Bedford Institute of Oceanography 2002 in Review.

PUBLICATIONS AND PRODUCTS

Cloutier, D., C.L. Amos, P.R. Hill, and K. Lee. 2003. Oil erosion in an annular flume by seawater of varying turbidities: A critical bed shear stress approach. Spill Sci. Technol. Bull. 8(1): 83-94.

Cranford, P.J., D.C. Gordon, Jr., C.G. Hannah, J.W. Loder, T.G. Milligan, D.K. Muschenheim, and Y. Shen. 2003. Modelling potential effects of petroleum exploration drilling on northeastern Georges Bank scallop stocks. Ecol. Model. 166: 19-39.

Curran, K.J., P.S. Hill, and T.G. Milligan. 2003. Time variation of floc properties in a settling column. J. Sea Res. 49: 1-9.

Gilkinson, K.D., G.B.J. Fader, D.C. Gordon, Jr., R. Charron, D. McKeown, D. Roddick, E.L.R. Kenchington, K. MacIsaac, C. Bourbonnais, P. Vass, and Q. Liu. 2003. Immediate and longer-term impacts of hydraulic clam dredging on an offshore sandy seabed: Effects on physical habitat and processes of recovery. Continental Shelf Res. 23: 1315-1336.

Greer, C.W., N. Fortin, R. Roy, L.G. Whyte, and K. Lee. 2003. Indigenous sediment microbial activity in response to nutrient enrichment and plant growth following a controlled oil spill on a freshwater wetland. Bioremed. J. 7(1): 69-80.

Guénette, C.C., G.A. Sergy, E.H. Owens, R.C. Prince, and K. Lee. 2003. Experimental design of the Svalbard Shoreline Project. Spill Sci. Technol. Bull. 8(3): 245-256.

Hellou, J., and R.J. Law. 2003. Stress on stress response of wild mussels, *Mytilus edulis* and *Mytilus trossulus*, as an indicator of ecosystem health. Environ. Poll. 126: 407-416.

Hellou, J., P. Yeats, S. Steller, and F. Gagne. 2003. Chemical contaminants and biological indicators of mussel health during gametogenesis. Environ. Toxicol. Chem. 22(9): 2080-2087.

Hill, P., A. Khelifa, and K. Lee. 2003. Time scale for oil droplet stabilization by mineral particles in turbulent suspension. Spill Sci. Technol. Bull. 8(1): 73-81.

Khelifa, A., P. Stoffyn-Egli, P.S. Hill, and K. Lee. 2003. Characteristics of oil droplets stabilized by mineral particles: Effect of oil types and temperature. Spill Sci. Technol. Bull. 8(1): 19-30.

Kepkay, P.E., J.B.C. Bugden, K. Lee, and P. Stoffyn-Egli. 2003. Application of Ultraviolet Fluorescence (UVF) spectroscopy to monitor Oil-Mineral Aggregate (OMA) formation. Spill Sci. Technol. Bull. 8(1): 101-108.

King, T.L., K. Lee, P. Yeats, and R. Alexander. 2003. Chlorobenzenes in snow crab (*Chionoecetes opilio*): Time-series monitoring following an accidental release. Bull. Environ. Contam. Toxicol. 71: 543-550.

Lee, K., P. Stoffyn-Egli, and E.H. Owens. 2002.* The OSSA II pipeline oil spill: Natural mitigation of a riverine oil spill by oil-mineral aggregate formation. Spill Sci. Technol. Bull. 7: 149-154.

Lee, K., G. Wohlgeschaffen, G.H. Tremblay, B.T. Johnson, G.A. Sergy, R.C. Prince, C.C. Guénette, and E.H. Owens. 2003. Toxicity evaluation with the microtox test to assess the impact of *in-situ* oiled shoreline treatment options: Natural attenuation and sediment relocation. Spill Sci. Technol. Bull. 8(3): 273-284.

Lee, K., P. Stoffyn-Egli, G.H. Tremblay, E.H. Owens, G.A. Sergy, C.C. Guénette, and R.C. Prince. 2003. Oil-mineral aggregate formation on oiled beaches: Natural attenuation and sediment relocation. Spill Sci. Technol. Bull. 8(3): 285-296.

Lee, K., R.C. Prince, C.W. Greer, K.G. Doe, J.E.H. Wilson, S.E. Cobanli, G.D. Wohlgeschaffen, D. Alroumi, T. King, and G.H. Tremblay. 2003. Composition and toxicity of residual Bunker C fuel oil in intertidal sediments after 30 years. Spill Sci. Technol. Bull. 8(2): 187-199.

Lee, K. 2003. Oil-particle interactions in aquatic environments: Influence on the transport, fate, effect and remediation of oil spills. Spill Sci. Technnol. Bull. 8(1): 3-8.

Lee, L.E.J., J. Stassen, A. McDonald, C. Culshaw, A.D. Venosa, and K. Lee. 2002.* Snails as biomonitors of oil-spill and bioremediation strategies. Bioremed. J. 6: 373-3.

Le Floch, S., J. Guyomarch, F.X. Merlin, P. Stoffyn-Egli, J. Dixon, and K. Lee. 2003. The influence of salinity on oil-mineral aggregate formation. Spill Sci. Technol. Bull. 8: 65-71.

* Citation year is 2002; however, publication occurred after publication of Bedford Institute of Oceanography 2002 in Review.

Le Floch, S., J.F. Børseth, P. Le Corre, and K. Lee. 2003. Effects of oil and bioremediation on mussel (*Mytilus edulis* L.) growth in mudflats. Environ. Technol. 24: 1211-1219.

Moran, S.B., S.E. Weinstein, H.N. Edmonds, J.N. Smith, R.P. Kelly, M.E.Q. Pilson, and W.G. Harrison. 2003. Does $^{234}Th/^{238}U$ disequilibrium provide an accurate record of the export flux of particulate organic carbon from the upper ocean? Limnol. Oceanogr. 48(3): 1018-1029.

Mueller, D.C., J.S. Bonner, S.J. McDonald, R.L. Autenrieth, K.C. Donnelly, K. Lee, K.G. Doe, and J. Anderson. 2003. The use of toxicity bioassays to monitor the recovery of oiled wetland sediments. Environ. Toxicol. Chem. 22(9): 1945-1955.

Muschenheim, D.K., and K. Lee. 2003. Removal of oil from the sea surface through particulate interactions: Review and prospectus. Spill Sci. Technol. Bull. 8(1): 9-18.

Owens, E.H., G.A. Sergy, C.C. Guénette, R.C. Prince, and K. Lee. 2003. The reduction of stranded oil by shoreline treatment options. Spill Sci. Technol. Bull. 8(3): 257-272.

Owens, E.H., and K. Lee. 2003. Interaction of oil and mineral fines on shorelines: Review and assessment. Mar. Pollut. Bull. 47(9-12): 397-405.

Prince, R.C., R.E. Bare, R.M. Garrett, M.J. Grossman, C.E. Haith, L.G. Keim, K. Lee, G.J. Holtom, P. Lambert, G.A. Sergy, E.H. Owens, and C.C. Guénette. 2003. Bioremediation of stranded oil on an arctic shoreline. Spill Sci. Technol. Bull. 8(3): 303-312.

Prince, R.C., R.M. Garrett, R.E. Bare, M.J. Grossman, T. Townsend, J.M. Sutlita, K. Lee, E.H. Owens, G.A. Sergy, J.F. Braddock, J.E. Lindstrom, and R.R. Lessard. 2003. The roles of photooxidation and biodegradation in long-term weathering of crude and heavy fuel oils. Spill Sci. Technol. Bull. 8(2): 145-156.

Ricking, M., J. Schwarzbauer, J. Hellou, A. Svenson, and V. Zitko. 2003. Polycyclic aromatic musk compounds in sewage treatment plant effluents of Canada and Sweden - first results. Mar. Pollut. Bull. 46: 410-417.

Schratzberger, M., E. Daniel, C.M. Wall, R. Kilbride, S.J. Macnaughton, S.E. Boyd, H.L. Rees, K. Lee, and R.P.J. Swannell. 2003. Response of estuarine meio- and macrofauna to *in situ* bioremediation of oil-contaminated sediment. Mar. Pollut. Bull. 46(4): 430-443.

Sergy, G.A., C.C. Guénette, E.H. Owens, R.C. Prince, and K. Lee. 2003. In-situ treatment of oiled sediment shorelines. Spill Sci. Technol. Bull. 8(3): 237-244.

Smith, J.N., S.B. Moran, and R.W. Macdonald. 2003. Shelf-basin interactions in the Arctic Ocean based on ^{210}Pb and Ra isotope tracer distributions. Deep-Sea Res. 50: 397-416.

Stark, A., T. Abrajano, Jr., J. Hellou, and J.L. Metcalf-Smith. 2003. Molecular and isotopic characterization of polycyclic aromatic hydrocarbon distribution and sources at the intertidal segment of the St. Lawrence River. Org. Geochem. 34: 225-237.

Stoffyn-Egli, P., and K. Lee. 2003. Observation and characterization of oil-mineral aggregates. Spill Sci. Technol. Bull. 8(1): 31-44.

Tay, K.-L., S.J. Teh, K. Doe, K. Lee, and P. Jackman. 2003. Histopathologic and histochemical biomarker responses of Baltic clam, *Macoma balthica*, to contaminated Sydney Harbour sediment, Nova Scotia, Canada. Environ. Health Perspect. 111: 273-280.

Departmental Reports:

Bancroft, D., R.A. Lake, S.-L. Marshall, and K. Lee. 2003. An overview of marine environmental research pertaining to West Coast offshore oil and gas development. Can. Tech. Rep. Fish. Aquat. Sci. 2480: iii + 45 p.

Department of Fisheries and Oceans, Science Branch, Maritimes Region. 2003. Salmon holding capacity in southwestern New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 2489: iv + 60 p.

Fisheries and Oceans Canada, Science Sector, Ottawa. 2003. A scientific review of the potential environmental effects of aquaculture in aquatic ecosystems. Vol. 1. Far-field environmental effects of marine finfish aquaculture (B.T. Hargrave); Ecosystems level effects of marine bivalve aquaculture (P. Cranford, M. Dowd, J. Grant, B. Hargrave and S. McGladdery); Chemical use in marine finfish aquaculture in Canada: A review of current practicies and possible environment al effects (L.E. Burridge). Can. Tech. Rep. Fish. Aquat. Sci. 2450: ix + 131 p.

King, T.L., and C.L. Chou. 2003. Anthropogenic organic contaminants in American lobsters (*Homarus americanus*) procured from harbours, bays, and inlets of eastern Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2456: vi + 24 p.

Special Publications:

Cretney, W., M. Yunker, and P. Yeats. 2002.* Biogeochemical benchmarks for source identification of contaminants from an offshore oil and gas industry. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/129. 26 p.

Books; Book Chapters:

Wassmann, P., E. Bauerfiend, M. Fortier, M. Fukuchi, B. Hargrave, B. Moran, T. Noji, E.-M. Nothig, K. Olli, R. Peinert, H. Sasaki, and V.P. Shevchenkop. 2003. Particulate organic carbon flux to the Arctic Ocean sea floor, p. 101-138. *In* R. Stein and R.W. Macdonald [ed.]. The Organic Carbon Cycle in the Arctic Ocean. Springer, Berlin.

Conference Proceedings:

Lee, K., A.D. Venosa, M.T. Suidan, S. Garcia-Blanco, C.W. Greer, G. Wohlgeschaffen, S.E. Cobanli, G.H. Tremblay, and K.G. Doe. 2003. Habitat recovery in an oil-contaminated salt marsh following bioremediation treatments. *In* Proceedings of the 2003 International Oil Spill Conference, Vancouver, B.C., April 7-10, 2003. American Petroleum Institute Publ. 14730B.

Khelifa, A.P. Stoffyn-Egli, K. Lee, and P. Hill. 2003. Characteristics of oil droplets stabilized by oil-mineral aggregation. *In* Proceedings of the 2003 International Oil Spill Conference, Vancouver, B.C., April 7-10, 2003. American Petroleum Institute Publ. 14730B.

Khelifa, A., M. Pahlow, A. Vezina, K. Lee, and C. Hannah. 2003. Numerical investigation of impact of nutrient inputs from produced water on the marine planktonic community. *In* Proceedings of the 26th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Victoria, B.C., June 10-12, 2003.

Khelifa, A., P. Hill, and K. Lee. 2003. A stochastic model to predict the formation of oil-mineral aggregates. *In* Proceedings of the 26th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Victoria, B.C., June 10-12, 2003.

Prince, R.C., J.R. Clark, and K. Lee. 2002.* Bioremediation effectiveness; removing hydrocarbons while minimizing environmental impact. *In* Proceedings of the Ninth International Petroleum Environmental Conference, Albuquerque, NM.

Ramachandran, S.D., P.V. Hodson, C.W. Khan, and K. Lee. 2003. PAH uptake by juvenile rainbow trout exposed to dispersed crude oil. *In* Proceedings of the 26th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, Victoria, B.C., June 10-12, 2003.

4) Ocean Sciences:

Recognized Scientific Journals:

Anderson, L.G., E.P. Jones, and J.H. Swift. 2003. Export production in the central Arctic Ocean evaluated from phosphate deficits. J. Geophys. Res. 108(C6).

Azetsu-Scott, K., R.M. Gershey, E.P. Jones, and I. Yashayaev. 2003. Time series study of CFC concentrations in the Labrador Sea during deep and shallow convection regimes (1991-2000). J. Geophys. Res. 108(C11).

Bouman, H.A., T. Platt, S. Sathyendranath, W.K.W. Li, V. Stuart, C. Fuentes-Yaco, H. Maass, E.P.W. Horne, O. Ulloa, V. Lutz, and M. Kyewalyanga. 2003. Temperature as indicator of optical properties and community structure of marine phytoplankton: Implications for remote sensing. Mar. Ecol. Prog. Ser. 258: 19-30.

Brickman, D. 2003. Controls on the distribution of Browns Bank juvenile haddock. Mar. Ecol. Prog. Ser. 263: 235-246.

* Citation year is 2002; however, publication occurred after publication of Bedford Institute of Oceanography 2002 in Review.

Cochrane, N.A., Y. Li, and G.D. Melvin. 2003. Quantification of a multibeam sonar for fisheries assessment applications. J. Acoust. Soc. Am. 114 (2): 745-758.

Cota, G.F., W.G. Harrison, T. Platt, S. Sathyendranath, and V. Stuart. 2003. Bio-optical properties of the Labrador Sea. J. Geophys. Res. 108: 21-1–21-14.

Cranford, P.J., D.C. Gordon, Jr., C.G. Hannah, J.W. Loder, T.G. Milligan, D.K. Muschenheim, and Y. Shen. 2003. Modelling potential effects of petroleum exploration drilling on Northeastern Georges Bank scallop stocks. Ecol. Model. 166: 19-39.

Greene, C.H., A.J. Pershing, A. Conversi, B. Planque, C. Hannah, D. Sameoto, E. Head, P.C. Smith, P.C. Reid, J. Jossi, D. Mountain, M.C. Benfield, P.H. Weibe, and E. Durbin. 2003. Trans-Atlantic responses of *Calanus finmarchicus* populations to basin-scale forcing associated with the North Atlantic Oscillation. Prog. Oceanogr. 58: 301-312.

Han, G., and J.W. Loder. 2003. Three-dimensional seasonal-mean circulation and hydrography on the eastern Scotian Shelf. J. Geophys. Res. 108(C5), 3136: 1-21.

Head, E.J.H., L.R. Harris, and I.M. Yashayaev. 2003. Distributions of *Calanus* spp. and other mesozooplankton in the Labrador Sea in relation to hydrography in spring and early summer (1995-2000). Prog. Oceanogr. 59: 1-30.

Jones, E.P., J.H. Swift, L.G. Anderson, M. Lipizer, G. Civitarese, K.K. Falkner, G. Kattner, and F. McLaughlin. 2003. Tracing Pacific water in the North Atlantic Ocean. J. Geophys. Res. 108(C4), 3116.

Krahmann, G., M. Visbeck, W. Smethie, E.A. D'Asaro, P.B. Rhines, R.A. Clarke, J. Lazier, R.E. Davis, P.P. Niiler, P.S. Guest, J. Meincke, G.W. Kent Moore, R.S. Pickart, W.B. Owens, M.D. Prater, I.A. Renfrew, and F.A. Schott. 2003. The Labrador Sea Deep Convection Experiment data collection. Geochem. Geophys. Geosyst. 4(10), 1091.

Lilly, J., P. Rhines, F. Schott, K. Lavender, J. Lazier, U. Send, and E. D'Asaro. 2003. Observations of the Labrador Sea eddy field. Prog. Oceanogr. 59(1): 75-176.

Lin, R.Q., and W. Perrie. 2003. Wave-current interactions in an idealized tidal estuary. J. Geophys. Res. (Oceans) 108: 3023-3041.

Lutz, V.A., S. Sathyendranath, E.J.H. Head, and W.K.W. Li. 2003. Variability in pigment composition and optical characteristics of phytoplankton in the Labrador Sea and the central North Atlantic. Mar. Ecol. Prog. Ser. 60: 1-18.

Loder, J.W., C.G. Hannah, B.D. Petrie, and E.A. Gonzalez. 2003. Hydrographic and transport variability on the Halifax section. J. Geophys. Res. 108(C11), 8003: 1-18.

McDougall, T.J., D.R. Jackett, D.G. Wright, and R. Feistel. 2003. Accurate and computationally efficient algorithms for potential temperature and density of seawater. J. Atmos. Ocean. Technol. 20: 730-741.

Melvin, G.D., N.A. Cochrane, and Y. Li. 2003. Extraction and comparison of acoustic backscatter from a calibrated multi- and single-beam sonar. ICES J. Mar. Sci. 60: 669-677.

Pahlow, M., and A. Vézina. 2003. Adaptive model of DOM dynamics in the surface ocean. J. Mar. Res. 61: 127-146.

Perrie, W., C.L. Tang, Y. Hu, and B.M. DeTracey. 2003. The impact of waves on surface currents. J. Phys. Oceanogr. 33: 2126-2141.

Peterson, I.K., S.J. Prinsenberg, and J.S. Holladay. 2003. Sea-Ice thickness measurement: Recent experiments using helicopter-borne EM-Induction sensors. Recent Res. Dev. Geophys. 5(2003): 1-20.

Platt, T., D.S. Broomhead, S. Sathyendranath, A.M. Edwards, and E.J. Murphy. 2003. Phytoplankton biomass and residual nitrate in the pelagic ecosystem. Proc. R. Soc. Lond. A. 459: 1063-1073.

Platt, T., C. Fuentes-Yaco, and K.T. Frank. 2003. Spring algal bloom and larval fish survival. Nature 423: 398-399.

Platt, T., S. Sathyendranath, A.M. Edwards, D.S. Broomhead, and O. Ulloa. 2003. Nitrate supply and demand in the mixed layer of the ocean. Mar. Ecol. Prog. Ser. 254: 3-9.

Tian, R.C., A.F. Vézina, D. Deibel, and R. Rivkin. 2003. Sensitivity of biogenic carbon export to ocean climate in the Labrador Sea, a deep-water formation region. Global Biogeochem. Cycles 17(4), 1090.

Vézina, A.F., and M. Pahlow. 2003. Reconstruction of ecosystem flows with inverse methods: How well do they work? J. Mar. Sys. 40-41: 55-77.

Yao, T., and C.L. Tang. 2003. The formation and maintenance of the North Water Polynya. Atmos.-Ocean 41: 187-201.

Yin, B., D. Yang, X. Lin, Y. Hou, and W. Perrie. 2003. Effects of wave-current interactions on bottom stress and currents. J. Hydrodynam. Ser. B(5): 13-19.

Departmental Reports:

Brickman, D., and B. Petrie. 2003. Nitrate, silicate and phosphate atlas for the Gulf of St. Lawrence. Can. Tech. Rep. Hydrogr. Ocean Sci. 231: xi + 152 p.

Casault, B., A.F. Vézina, and B. Petrie. 2003. Atlas of surface mixed layer characteristics for the Scotian Shelf and the Gulf of Maine. Can. Data Rep. Hydrogr. Ocean Sci. 164: v + 306 p.

Chaffey, J.D., and D.A. Greenberg. 2003. Resolute: A semi-automated finite element mesh generation routine. Can. Tech. Rep. Hydrogr. Ocean Sci. 225: vi + 33 p.

Dupont, F., B. Petrie, and J. Chaffey. 2003. Modelling the tides of the Bras d'Or Lakes. Can. Tech. Rep. Hydrogr. Ocean Sci. 230: viii + 53 p.

Hamilton, J., S. Prinsenberg, and L. Malloch. 2003. Moored current meter and CTD observations from Barrow Strait, 1999-2000. Can. Data Rep. Hydrogr. Ocean Sci. 161: v + 60 p.

Hannah, C.G., A. Drozdowski, D.K. Muschenheim, J.W. Loder, S. Belford, and M. MacNeil. 2003. Evaluation of drilling mud dispersion models at SOEI Tier I sites: Part 1 North Triumph, fall 1999. Can. Tech. Rep. Hydrogr. Ocean Sci. 232: v + 51 p.

Hannah, C.G., D.R. Lynch, and K. Smith. 2003. The CASCO4b user's guide. Can. Tech. Rep. Hydrogr. Ocean Sci. 226: vii + 80 p.

Hayden, H.B., D.J. Belliveau, and S.J. Prinsenberg. 2003. Ice drift and draft measurements from moorings at the Confederation Bridge January – March 2002. Can. Data. Rep. Hydrogr. Ocean. Sci. 163: iv + 209 p.

Ouellet, M., B. Petrie, and J. Chassé. 2003. Temporal and spatial scales of sea-surface temperature variability in Canadian Atlantic waters. Can. Tech. Rep. Hydrogr. Ocean Sci. 228: v + 30 p.

Smith, P.C., M. Black, R. Pettipas, F. Page, and K.F. Drinkwater. 2003. Redfish environmental associations and exposure histories, p. 83-88. *In* D. Gascon [ed.] Redfish Multidisciplinary Zonal Research Program (1995-1998): Final Report. Can. Tech. Report Fish. Aquat. Sci. 2462.

Tedford, T., A. Drozdowski, and C.G. Hannah. 2003. Suspended sediment drift and dispersion at Hibernia. Can. Tech. Rep. Hydrogr. Ocean Sci. 227: vi + 57 p.

Van der Baaren A., B. Petrie, and S.J. Prinsenberg. 2003. Low-frequency variability in Lancaster Sound. Can. Tech. Rep. Hydrogr. Ocean Sci. 223: xii + 124 p.

Special Publications:

Hannah, C.G. [ed.]. 2003. Report of the Study Group on Modelling Physical/Biological Interactions (SGPBI). Int. Counc. Explor. Sea C.M.2001/C:04.

Hannah, C.G. 2003. Strategy for modelling physical-biological interactions. Int. Counc. Explor. Sea C.M.2003/P:04.

Harrison, G., D. Sameoto, J. Spry, K. Pauley, H. Maass, and V. Soukhovtsev. 2003. Optical chemical and biological oceanographic conditions in the Maritimes/Gulf Regions in 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003072. 49 p.

Hendry, R.M., R.A. Clarke, J.R.N. Lazier, and I.M. Yashayaev. 2003. Environmental conditions in the Labrador Sea in spring 2002. DFO Can. Sci. Advis. Sec. Res. Doc. 2003/044. 29 p.

Kohl, A., D. Satmmer, B. Cornuelle, E. Remy, Y. Lu, P. Heimbach, and C. Wunsch. 2003. The global 1-degree WOCE synthesis: 1992-2001. ECCO (Est. Circ. Clim. Ocean) Rep. Ser. 18.

Prinsenberg, S.J., and J. Hamilton. 2003. Oceanic fluxes through Lancaster Sound of the Canadian Arctic Archipelago. Arctic & Sub-Arctic Ocean Flux (ASOF) Newsletter 2. 6 p.

Books; Book Chapters:

Toba, Y., S.D. Smith, and N. Ebuchi. 2003. Historical drag expressions, p. 35-53. *In* I.S.F. Jones and Y. Toba [ed.]. Wind Stress Over the Ocean. Cambridge Univ. Press. 307 p.

Conference Proceedings:

Khelifa, A., M. Pahlow, A. Vezina, K. Lee, C. Hannah. 2003. Numerical investigation of environmental impact of produced water from offshore oil and gas exploitations on marine ecosystems, p. 323-333. *In* Proceedings of the 26th Arctic and Marine Oilspill Program Technical Seminar, Victoria, B.C., June 10-12, 2003.

Prinsenberg, S.J. 2003. Canadian Arctic Throughflow Study (CATS-BIO), a contribution to ASOF-West. *In* Report to ASOB (J. Cooley), ACSYS-CLIC (E. Fharbach), SEARCH (J. Morison), and PERD CCIS POL (R.A. Clarke). 6 p.

Prinsenberg, S.J., and J. Hamilton. 2003. Volume, freshwater and heat fluxes through Lancaster Sound in the Canadian Arctic Archipelago. *In* Proceedings of the 2003 ACSYS Final Science Conference, St. Petersburg, Russia, Nov. 11-14, 2003.

Prinsenberg, S.J., and I.K. Peterson. 2003. Comparing ice chart parameters against ice observations, p. 733-738. *In* Proceedings of the 13th Int. Offshore and Polar Eng. Conf. (ISOPE-2003) 1, Honolulu, HI.

Yashayaev, I., J.R.N. Lazier, and R.A. Clarke. 2003. Temperature and salinity in the central Labrador Sea during the 1990s and in the context of the longer term change. Int. Counc. Explor. Sea. Mar. Sci. Symp. 219: 32-39.

Oceans and Environment Branch

Conference Proceedings:

Rutherford, R.J., S. Coffen-Smout, G. Herbert, B.L. Smith, 2003. Proceedings of the 2nd Eastern Scotian Shelf Integrated Management (ESSIM) Forum Workshop, Halifax, Nova Scotia, February 18-19, 2003.

ENVIRONMENT CANADA AT BIO

Departmental Reports:

Young, J.H., D. MacArthur, R. Gaudet and D. Walter. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sector 04-020-003 Tracadie Harbour. Manuscript Report No. EP-AR-2003-4. 18 p.

Young, J.H., D. MacArthur, R. Gaudet and D. Walter. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sector 11-060-005 Clam Harbour. Manuscript Report No. EP-AR-2003-5. 16p.

MacArthur, D., Craig,C, Walter, D. and C. Dennis. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Area 7 (Bras d'Or Lakes, Volume 5). Manuscript Report No. EP-AR-2003-6. 219p.

Young, J.H., D. MacArthur, R. Gaudet and D. Walter. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sector 11-040-002 Liscomb Harbour / Spanish Ship Bay. Manuscript Report No. EP-AR-2003-7. 15p.

MacArthur, D., C. Craig, D. Walter and C. Dennis. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Area NS-07-030-004 St. Peters Inlet/ Chapel Island. Manuscript Report No. EP-AR-2003-8. 20p.

MacArthur, D., A.S. Menon, J.H. Young and R. Gaudet. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Area NS-16-020-003 Grosses Coques/ Belliveau's Cove. Manuscript Report No. EP-AR-2003-9. 25 p.

Young, J.H., D. MacArthur, D. Walter and R. Gaudet. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sector 18-010-001 Annapolis Basin. Manuscript Report No. EP-AR-2003-10. 30 p.

Young, J.H., D. MacArthur, R. Gaudet and D. Walter. 2003. Re-evaluation Report of Nova Scotia Shellfish Growing Area Sectors 1-010 to 4-030 (Northumberland Strait- St. Georges Bay). Manuscript Report No. EP-AR-2003-11.

Young, J.H., D. MacArthur, R. Gaudet and D. Walter. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sectors 10-010 to 11-060 (Eastern Shore: Guysborough- Jeddore). Manuscript Report No. EP-AR-2003-12.

Craig, C., B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-01-020-001 Kildare River. Manuscript Report No. EP-AR-2003-13. 18 p.

Craig, C., A. Menon and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-02-010-003 Grand River/ West Malpeque. Manuscript Report No. EP-AR-2003-14. 19 p.

Craig, C., A. Menon, B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-05-010-002 Basin Head/ Little Harbour. Manuscript Report No. EP-AR-2003-15. 17 p.

Craig, C., B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-05-020-002 Rollo Bay/ Fortune River. Manuscript Report No. EP-AR-2003-16. 17 p.

Craig, C., A. Menon, B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-07-010-002 Pownal Bay. Manuscript Report No. EP-AR-2003-17. 16 p.

Craig, C., A. Menon, B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-07-020-003 Hillsborough River. Manuscript Report No. EP-AR-2003-18. 22 p.

Craig, C., A. Menon, B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-09-020-001 Cap Egmont/ Haldimand River. Manuscript Report No. EP-AR-2003-19. 17 p.

Craig, C., A. Menon, B. Raymond and R. Gaudet. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Area Subsector PE-09-040-001 Brae Harbour/ Wolfe Inlet. Manuscript Report No. EP-AR-2003-20. 18 p.

Craig, C., R. Gaudet, A. Menon and B. Raymond. 2003. Re-evaluation Report Prince Edward Island Shellfish Growing Areas 7 to 9. Manuscript Report No. EP-AR-2003-21. 160 p.

Young, J.H., D. Walter and R. Gaudet. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Sector 13-030-004 Lunenburg Bay. Manuscript Report No. EP-AR-2003-22. 24p.

MacArthur, D., C. Craig and D. Walter. 2003. Re-evaluation Report Nova Scotia Shellfish Growing Area NS-08-020-003 Morien Bay. Manuscript Report No. EP-AR-2003-23. 17 p.

NATURAL RESOURCES CANADA

Recognized Scientific Journals:

Amos, C.L., M.Z. Li, F.L. Chiocci, G.B. LaMonica, S. Cappucci, E.H. King, and F. Corbani. 2003. Origin of shore-normal channels from the shoreface of Sable Island, Canada. Journal of Geophysical Research, v. 108(C3), doi: 10.1029/2001JC001259.

Andrews, J.T. and B. MacLean. 2003. Hudson Strait ice streams: a review of stratigraphy, chronology, and links with North Atlantic Heinrich events. Boreas, v. 32, p. 4-17. (Oslo ISSN 0300-9483).

Atkinson, D.E. and S.E. Solomon. 2003. A Circum-Arctic environmental forcing database for coastal morphological prediction: development and preliminary analyses. Berichte zur Polar und Meeresforschung, 443(2003), Alfred Wegener Institute, Bremerhaven: p. 19-24.

Brown, R., J. McClintock, T. Bullock, and G. Sonnichsen. 2003. Prioritization of iceberg grounding events from ice season documentation. 17th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC'03), v. 2, p. 667-678.

Dehler, S.A. 2003. Aeromagnetism (compiler). In: International association of Geomagnetism and Aeronomy Activities in Canada: 1999-2003, compiled by R.J. Enkin and R.E. Horita. CNC/IUGG 2003 Quadrennial Report.

Deptuck, M., R.A. MacRae, J. Shimeld, G.L. Williams, and R.A. Fensome. 2003. Revised Upper Cretaceous and Lower Paleogene lithostratigraphy and depositional history of the Jeanne d'Arc Basin, offshore Newfoundland, Canada. American Association of Petroleum Geologists Bulletin, v. 87, no. 9, p. 1459-1483.

Dypvik, H. and L.E. Jansa. 2003. Sedimentary signature and processes during marine bolide impacts: a review. Sedimentary Geology, v. 161, p. 309-337.

Eaton, D.W., B. Milkereit, and M. Salisbury. 2003. Seismic methods for deep mineral exploration: Mature technologies adapted to new targets. The Leading Edge, v. 22, p. 580-585.

Eaton, D.W., B. Milkereit, and M. Salisbury. 2003. Hardrock seismic exploration: Mature technologies adapted to new exploration targets. In: Eaton, D.W., B. Milkereit, and M. Salisbury, Eds., Hardrock Seismic Exploration, Society of Exploration Geophysicists, Tulsa, p. 1-6.

Falcon-Lang, H.J., R.A. Fensome, and D.V. Venugopal. 2003. The Cretaceous age of the Vinegar Hill silica sand deposit, southern New Brunswick: evidence from palynology and paleobotany. Atlantic Geology, v. 39, p. 39-46.

John, U., R.A. Fensome, and L. Medlin. 2003. The application of a molecular clock based on molecular sequences and the fossil record to explain biogeographic distributions within the *Alexandrium tamarense* "species complex" (Dinophyceae). Molecular Biology and Evolution, v. 20, no. 7, p. 1015-1027.

King, A.D., R. McKenna, I. Jordaan, and G. Sonnichsen. 2003. A model for predicting iceberg grounding rates on the seabed. 17th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC'03), v. 2, p. 679-688.

Kostylev, V.E., R.C. Courtney, G. Robert, and B.J. Todd. 2003. Stock evaluation of giant scallop (*Placopecten magellanicus*) using high-resolution acoustics for seabed mapping. Fisheries Research, v. 60, p. 479-492.

Lowe, C., S.A. Dehler, and B.C. Zelt. 2003. Basin architecture and density structure beneath the Strait of Georgia, British Columbia. Canadian Journal of Earth Sciences, v. 40, p. 965-981.

Manson, G.K., D.L. Forbes, S.M. Solomon, D.E. Atkinson, and M. Craymer, M. 2003. Spatial trends in the variability of sea level, sea ice, coastal storms, and shoreline mobility in the western Canadian Arctic. Proceedings, Canadian Coastal Conference 2003, Kingston, Ontario, 16 p. (on CD-ROM).

O'Reilly, C.T., D.L. Forbes, and G.S. Parkes. 2003. Mitigation of coastal hazards: adaptation to rising sea levels, storm surges, and shoreline erosion. Proceedings, 1st Coastal, Estuary and Offshore Engineering Specialty Conference, Moncton, NB, Canadian Society for Civil Engineering, CSN-410, 10 p. (on CD-ROM).

Pe-Piper, G. and D.J.W. Piper. 2003. A synopsis of the geology of the Cobequid Highlands, Nova Scotia. Atlantic Geology, v. 38, p. 145-160.

Pichevin, L., T. Mulder, B. Savoye, A. Gervais, M. Cremer, and D.J.W. Piper. 2003. The Golo submarine turbidite system (east Corsica margin): morphology and processes of terrace formation from high-resolution seismic reflection profiles. Geo-Marine Letters v. 23, p. 117-124.

Pickrill, R.A. and B.J. Todd. 2003. The multiple roles of acoustic mapping in integrated ocean management, Scotian Shelf, Canada. Ocean and Coastal Management, v. 46, p. 601-614.

Pickrill, R.A. 2003. Integrated Seafloor Mapping: a tool for sustainable management of our offshore lands. Proceedings, Coasts and Ports, Australasian Conference, Auckland, N.Z. 8 p.

Piper, D.J.W. and C. Perissoratis. 2003. Quaternary neotectonics of the South Aegean arc. Marine Geology, 198, 259-288.

Piper, D.J.W. and M. DeWolfe. 2003. Petrographic evidence from the eastern Canadian margin of shelf-crossing glaciations. Quaternary International, v. 99-100, p. 99-113.

Rashid, H., R. Hesse, and D.J.W. Piper. 2003. Evidence for an additional Heinrich Event between H5 and H6: global implication. Paleoceanography, v. 18,1077, 15p.

Rashid, H., R. Hesse, and D.J.W. Piper. 2003. Origin of unusually thick Heinrich layers in ice-proximal regions of the northwest Labrador Sea. Earth and Planetary Science Letters, v. 208, p. 319-336.

Riding, J.B. and R.A. Fensome. 2003. A review of Scriniodinium Klement 1957, Endoscrinium (Kelment 1960) Vozzhennikova 1967 and related dinoflagellate taxa. Palynology, v. 26, p. 5-33.

Roberts, B., E. Zalewski, G. Perron, E. Adam, L. Petrie, and M. Salisbury. 2003. Seismic exploration of the Manitouwadge greenstone belt, Ontario: a case history. In: Eaton, D.W., Milkereit, B., and Salisbury, M., eds., Hardrock Seismic Exploration, Society of Exploration Geophysicists, Tulsa, p. 110-126.

Salisbury, M., C.W. Harvey, and L. Matthews. 2003. The acoustic properties of ores and host rocks in hardrock terranes. In: Eaton, D.W., B. Milkereit, and M. Salisbury, eds., Hardrock Seismic Exploration, Society of Exploration Geophysicists, Tulsa, p. 9-19.

Skene, K.I. and D.J.W. Piper. 2003. Late Quaternary stratigraphy of Laurentian Fan: a record of events off the eastern Canadian continental margin during the last deglacial period. Quaternary International, v. 99-100, p. 135-152.

Sonnichsen, G., R. Myers, K. Simpson, R. Brown, J. McClintock, T. Bullock, and P. Rudkin. 2003. Seabed surveys to document groundings from the 2000 Grand Bank Iceberg Season. 17th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC'03), v. 2, p. 655-666.

St-Onge, G., T. Mulder, D.J.W. Piper, C. Hillaire-Marcel, and J.S. Stoner, 2003. Earthquake and flood-induced turbidites in the Saguenay fiord, Québec: a Holocene paleoseismicity record. Quaternary Science Reviews, v. 23, p. 283-294.

Taylor, R.B., D. Frobel, and A.O. Brown. 2003. Monitoring shoreline change in Nova Scotia and its application to coastal engineering: First Coastal, Estuary and Offshore Engineering Specialty Conference of the Canadian Society for Civil Engineering, 31st annual conference Abstracts Volume p. 252 and paper on CD, 10p.

Webster, T.L., S. Dickie, C. O'Reilly, D. Forbes, G. Parkes, D. Poole, and R. Quinn. 2003. Mapping storm surge flood risk using a LIDAR-derived DEM. Elevation, supplement to Geospatial Solutions (May 2003), 5 p. (np).

Zelilidis, A., D.J.W. Piper, I. Vakalis, P. Avramidis, and K. Getsos. 2003. Oil and gas plays in Albania: do equivalent plays exist in Greece? Journal of Petroleum Geology, v. 26, p. 20-48.

Geological Survey of Canada (GSC) Open File Reports:

Avery, M.P. Vitrinite Reflectance (Ro) of dispersed organic matter from Canterra PCI St. George J-55. GSC Open File Report No. 1632, 15 pages.

Avery, M.P. Vitrinite Reflectance (Ro) of dispersed organic matter from Petro-Canada et al. Bonnett P-23. GSC Open File Report No. 1793, 13 pages.

Edwards, T., C.D. Jauer, P. Moir, H. Wielens. East Coast Basin Atlas Series: Grand Banks of Newfoundland Tectonic Elements. GSC Open File Report No. 1795, 1 map.

Fader, G.B.J., contribution from E.L. King. The mineral potential of The Gully Marine Protected Area, a submarine canyon of the outer Scotian Shelf. GSC Open File Report No. 1634, 1 CD.

Giles, P.J. and J. Utting. Carboniferous stratigraphy of the Bradelle L-49 and Brion Island wells, Central and Northern Gulf of St. Lawrence, Maritimes Basin, Eastern Canada. GSC Open File Report No. 1679, 1 poster.

Giles, P.S. Stratigraphic and structural interpretation of the H B Fina Northumberland Strait F-25 well, Western Maritimes Basin, Eastern Canada. GSC Open File Report No. 1840, 1 poster.

Jackson, H.R. et al. Cruise Report *Hudson* 2003-047: NUGGET (Nunavut to Greenland Geophysical Transect). GSC Open File Report No. 1838, 1 CD.

Jackson, H.R. et al. Cruise Report: *Hudson* 2002-011 Flemish Cap margin transect (Flame). GSC Open File Report No. 4426.

Li, M.Z., E.L. King, C. Smyth. Morphology and stability of sand ridges on Sable Island Bank, Scotian Shelf. GSC Open File Report No. 1836, 52 pages.

Miller, R.O. CCGS *Hudson* cruise 2002-021. A geological and geophysical survey on Sable Island Bank. GSC Open File Report No. 1524.

Rochon, A., S. Blasco, P. Travaglini. Cruise MR02-K05 onboard the RV *Mirai*: Joint Western Arctic Climate Study (JWACS) 2002. Geoscience Program - Leg 2 - Tuktoyaktuk (Northwest Territories) to Dutch Harbour (Alaska). GSC Open File Report No. 1781, 1 CD.

Smyth, C.E., M.Z. Li, D.E. Heffler. A summary of the 2001 Sable Island Bank hydrodynamic and bedform data. GSC Open File Report No. 1788, 48 pages.

Smyth, C., W. MacKinnon, and A. Robertson. Optical backscatter sensor calibration. GSC Open File Report No. 4548, 7 pages.

Solomon, S.M. The mineral potential of the proposed Mackenzie Delta Protected Areas. GSC Open File Report No. 1820, 1 CD.

Todd, B.J., K.W. Asprey, A.S. Atkinson, R. Blasco, P.R. Girouard, V.E. Kostylev, O. Longva, T. Lynds, W.A. Rainey, P.L. Spencer, M.S. Uyesugi, and P.C. Valentine. 2003. Expedition report CCGS *Hudson* 2002-026: Gulf of Maine. GSC Open File 1468, 143 p., 7 CD-ROMs.

Todd, B.J., J.A.M. Hunter, R.L. Good, R.A. Burns, M. Douma, S.E. Pullen, and C.F.M. Lewis. 2003. Seismostratigraphy of Quaternary sediments beneath Lake Simcoe, Ontario: results of the 1992 and 1993 expeditions of the MV *J. Ross Mackay*. GSC Open File 3037, 105 p., 1 CD-ROM.

Toews, M. Late Cenozoic geology of Salar Basin, eastern slope of the Grand Banks of Newfoundland. GSC Open File Report No. 1675, 47 pages.

Wielens, J.B.W. and M.P. Avery. Maturity trends from vitrinite data on the Northern Grand Banks. GSC Open File Report No. 4488, 1 CD or 1 poster.

Williams, G.L. Palynological analysis of Canterra PCI St. George J-55, Carson Basin, Grand Banks of Newfoundland. GSC Open File Report No. 1657, 18 pages, 1 poster.

Williams, G.L. Palynological analysis of Amoco-Imperial-Skelly Skua E-41, Carson Basin, Grand Banks of Newfoundland. GSC Open File Report No. 1658, 20 pages, 1 poster.

Williams, G.L. Palynological analysis of Elf Hermine E-94, Scotian Basin. GSC Open File Report No. 1654, 7 pages, 1 poster.

Williams, G.L. Palynological analysis of Petro-Canada et al. Terra Nova K-18, Jeanne d'Arc Basin, Grand Banks of Newfoundland. GSC Open File Report No. 1659, 19 pages, 1 poster.

GSC Current Research:

Piper, D.J.W. and S. Ingram. 2003. Major Quaternary sediment failures on the East Scotian Rise. Geological Survey of Canada Current Research, 2003-D01, 9 pp.

Books, Book Chapters, and Book Reviews:

Dehler, S.A. 2003. A review of non-volcanic rifting of continental margins: a comparison of evidence from land and sea, edited by Wilson, R.C.L., R.B. Whitmarsh, B. Taylor, and N. Froitzheim, Geological Society of London, Special Publication, No. 187, 2001. Geoscience Canada, v. 30, p. 30-31.

Eaton, D.W., B. Milkereit, and M. Salisbury, Eds. 2003. Hardrock Seismic Exploration, Society of Exploration Geophysicists, Tulsa. 270 p.

PUBLICATIONS AND PRODUCTS

Jenner, K.A., A.G. Sherin, and T. Horsman. 2003. The use of dynamic segmentation in the Coastal Information System: adjacency relationships from southeastern Newfoundland, Canada. In: Green, D.R. and S.D. King (eds.), Coastal and Marine Geo-Information Systems, Chapter 26, p. 371-384.

Piper, D.J.W., D.C. Mosher, B.J. Gauley, K. Jenner, and D.C. Campbell, 2003. The chronology and recurrence of submarine mass movements on the continental slope off southeastern Canada. In: Locat, J. and J. Mienert. Submarine mass movements and their consequences. Kluwer, Dordrecht, p. 299-306.

Piper, D.J.W. and C. McCall. 2003. A synthesis of the distribution of submarine mass movements on the eastern Canadian margin. In: Locat, J. and J. Mienert, Submarine mass movements and their consequences. Kluwer, Dordrecht, p. 291-298.

Schafer, C.T. 2003. Coastal Environment-Environmental problems in coastal regions IV (Book Review). CMOS Bulletin, v.31, no.4, p112-113.

Products 2003

FISHERIES AND OCEANS CANADA – MARITIMES REGION

Canadian Hydrographic Service

Tide Tables:

2003. Canadian tide and current tables (2003) Vol. 1. Atlantic Coast and Bay of Fundy. Canadian Hydrographic Service, Fisheries and Oceans, 615 Booth Street, Ottawa, ON K1A 0E6, Canada.

2003. Canadian tide and current tables (2003) Vol. 2. Gulf of St. Lawrence, Canadian Hydrograhic Service, Fisheries and Oceans, 615 Booth Street, Ottawa, ON K1A 0E6, Canada

CHS Charts – 2003:

Chart No. 4000. Gulf of Maine to/à Baffin Bay/Baie de Baffin. NEW EDITION

Chart No. 4003. Cape Breton to/à Cape Cod. NEW EDITION

Chart No. 4006. Newfoundland and Labrador/Terre-Neuve-et-Labrador to Bermuda/aux Bermuda. NEW EDITION

Chart No. 4010. Bay of Fundy/Baie de Fundy (Inner portion/partie intérieure). NEW EDITION

Chart No. 4011. Approaches to/Approches à Bay of Fundy/Baie de Fundy. NEW EDITION

Chart No. 4012. Yarmouth to/à Halifax. NEW EDITION

Chart No. 4015. Sydney to/à Saint-Pierre. NEW EDITION

Chart No. 4016. Saint-Pierre to/à St. John's. NEW EDITION

Chart No. 4017. Cape Race to/à Cape Freels. NEW EDITION

Chart No. 4022. Cabot Strait and approaches/Détroit de Cabot et les approches, Scatarie Island to/à Anticosti Island/Île D'Anticosti. NEW EDITION

Chart No. 4045. Sable Island Bank/Banc de l'Ile de Sable to/au St.Pierre Bank/Banc de Saint Pierre. NEW EDITION

Chart No. 4211. Cape Lahave to/à Liverpool Bay. NEW EDITION

Chart No. 4266. Sydney Harbour. NEW EDITION

Chart No. 4306. Strait of Canso and/et Southern Approaches/les approches sud. NEW EDITION

Chart No. 4308. St. Peters Bay to/à Strait of Canso. NEW EDITION

Chart No. 4340. Grand Manan. NEW EDITION

Chart No. 4363. Cape Smokey to/à St. Paul Island. NEW EDITION

Chart No. 4367. Flint Island to/à Cape Smokey. NEW EDITION

Chart No. 4379. Liverpool Harbour. NEW EDITION

Chart No. 4381. Mahone Bay. NEW EDITION

Chart No. 4384. Pearl Island to/à Cape La Have. NEW EDITION

Chart No. 4395. Lahave River Riverport to/à Conquerall Bank. NEW EDITION

Chart No. 4403. East Point to/à Cape Bear. NEW EDITION

Chart No. 4405. Pictou Island to/aux Tryon Shoals. NEW EDITION

Chart No. 4437. Pictou Harbour. NEW EDITION

Chart No. 4445. Merigomish Harbour. NEW EDITION

Chart No. 4450. St. Paul Island. NEW EDITION

Chart No. 4460. Charlottetown Harbour. NEW EDITION

Chart No. 4462. George's Bay NEW EDITION

Chart No. 4463. Chéticamp to/à Cape Mabou. NEW EDITION

Chart No. 4464. Chéticamp to/à Cape St. Lawrence. NEW EDITION

Chart No. 4466. Hillsborough Bay. NEW EDITION

Chart No. 4467. Rustico Bay and/et New London Bay. NEW EDITION

Chart No. 4483. Caribou Harbour. NEW EDITION

Chart No. 4497. Amet Sound. NEW EDITION

Chart No. 4498. Pugwash Harbour and approaches/et les approches. NEW EDITION

Chart No. 4504. Great Cat Arms and/et Little Cat Arm. NEW EDITION

Chart No. 4509. Pistolet Bay. NEW EDITION

Chart No. 4512. Quirpon Harbour and Approaches/et les approches. NEW EDITION

Chart No. 4514. St. Anthony Bight and Harbour. NEW EDITION

Chart No. 4521. Baie Verte. NEW EDITION

Chart No. 4522. Tilt Cove and/et La Scie Harbour. NEW EDITION

Chart No. 4524. Botwood Harbour. NEW EDITION

Chart No. 4529. Fogo Harbour Seal Cove and Approaches/et les approches. NEW EDITION

Chart No. 4531. Carmanville to/à Bacalhao Island and/et Fogo NEW EDITION

Chart No. 4538. Canada Bay including/y compris Chimney Bay. NEW EDITION

Chart No. 4541. Sops Arm. NEW EDITION

Chart No. 4542. Hampden Bay. NEW EDITION

Chart No. 4582. Plans - Notre Dame Bay. NEW EDITION

Chart No. 4584. White Bay - Southern Part/Partie Sud. NEW EDITION

Chart No. 4585. Green Head to/à Little Bay Island. NEW EDITION

Chart No. 4587. Mortier Bay. NEW EDITION

Chart No. 4592. Little Bay Island to/à League Rock. NEW EDITION

Chart No. 4594. Thimble Tickles to/à Bagg Head including/y compris New Bay. NEW EDITION

Chart No. 4595. Bay of Exploits Sheet/Feuille I (North-Nord). NEW EDITION

Chart No. 4596. Bay of Exploits Sheet/feuille II (Middle/centre). NEW EDITION

Chart No. 4597. Bay of Exploits Sheet/feuille III (South/sud). NEW EDITION

Chart No. 4616. Burin Harbours and Approches/et les approches. NEW EDITION

Chart No. 4622. Cape St. Mary's to/à Argentia Harbour and/et Jude Island. NEW EDITION

Chart No. 4625. Burin Penninsula to/à Saint-Pierre. NEW EDITION

Chart No. 4626. Saint-Pierre and/et Miquelon (France). NEW EDITION

Chart No. 4633. Ramea Islands to/à Bonne Bay. NEW EDITION

Chart No. 4635. Cape Ray to/à La Poile Bay. NEW EDITION

Chart No. 4638. Wreck Island to/à Cinq Cerf Bay. NEW EDITION

Chart No. 4643. Ile Saint-Pierre (France). NEW EDITION

Chart No. 4652. Humber Arm Meadows Point to/à Humber River. NEW EDITION

Chart No. 4653. Bay of Islands. NEW EDITION

Chart No. 4658. Bonne Bay. NEW EDITION

Chart No. 4659. Port au Port. NEW EDITION

Chart No. 4661. Bear Head to/à Cow Head. NEW EDITION

Chart No. 4663. Cow Head to/à Pointe Riche. NEW EDITION

Chart No. 4665. St. Margaret Bay and Approaches/et les approches. NEW EDITION

Chart No. 4666. St Barbe Point to/à Old Férolle Harbour. NEW EDITION

Chart No. 4667. Savage Cove to/à St. Barbe Bay. NEW EDITION

Chart No. 4668. Anchorages/Mouillages in the/dans le Strait of Belle Isle/Détroit de Belle Isle.. NEW EDITION

Chart No. 4670. Forteau Bay. NEW EDITION

Chart No. 4680. Hawkes Bay to/à Ste Geneviève Bay including/ycompris St John Bay. NEW EDITION

Chart No. 4682. Larkin Point to/à Cape Anguille. NEW EDITION

Chart No. 4700. Belle Isle to/à Resolution Island. NEW EDITION

Chart No. 4702. Corbet Island to/à Ship Harbour Head. NEW EDITION

Chart No. 4703. White Point to/à Corbet Island. NEW EDITION

Chart No. 4731. Forteau Bay to/à Domino Run. NEW EDITION

Chart No. 4732. Approaches to/Approches à Hamilton Inlet. NEW EDITION

Chart No. 4745. White Point to/à Sandy Island. NEW EDITION

Chart No. 4766. Saglek Bay. NEW EDITION

Chart No. 4767. Saglek Bay Anchorage/Mouillage. NEW EDITION

Chart No. 4771. Eclipse Harbour to/à Cape White Handkerchief. NEW EDITION

Chart No. 4774. Approaches to/approches à Williams Harbor. NEW EDITION

Chart No. 4839. Head of/Fond de Placentia Bay. NEW EDITION

Chart No. 5001. Labrador Sea/Mer du Labrador. NEW EDITION

Chart No. 5032. Approaches to/à White Bear Arm. NEW CHART

Chart No. 5033. Hawke Bay and/et Squasho Run. NEW CHART

Chart No. 5042. Cut Throat Island to/à Quaker Hat. NEW EDITION

Chart No. 5133. Domino Point to/à Cape North. NEW EDITION

Chart No. 5140. South Green Island to/à Ticoralak Island. NEW EDITION

Chart No. 5143. Lake Melville. NEW EDITION

Chart No. 5179. Alexis Bay and/et Alexis River. NEW EDITION

Chart No. 8005. Georges Bank. NEW EDITION

Chart No. 8006. Scotian Shelf/Plate-Forme Néo-Écossaise, Browns Bank to Emerald Bank/Banc de Brown au Banc D'Emeraude. NEW EDITION

Chart No. 8014. Grand Banc/Grand Bank (Northeast Portion/Partie-nord-est). NEW EDITION

Chart No. 8046. Button Islands to/à Cod Island. NEW EDITION

Chart No. 8047. Cod Island to/à Cape Harrison. NEW EDITION

Chart No. 8048. Cape Harrison to/à St. Michael Bay. NEW EDITION

Chart No. 8049. St. Michael Bay to/aux Gray Islands. NEW EDITION

S57 ENCs (Electronic Navigational Charts) – 2003[1]:

CA276286. Chart No. 4023. Northumberland Strait

CA576007. Chart No. 4203. Marine Atlantic Terminal

CA576268. Chart No. 4920. Wharf Belledune

CA376330. Chart No. 4340. Grand Manan

[1]Available from Nautical Data International Inc. (http://www.digitalocean.ca).

Pioneer Nova Scotian geologist, John William Dawson (standing), Victorian geologist Sir Charles Lyell (kneeling), and assistant (with hat) discover fossil vertebrates in the infilling of a fossil tree trunk at Coal Mine Point, Joggins, circa 1852.

Painting by New Brunswick artist Judi O. Pennanen from the book The Last Billion Years, *courtesy of the Geological Survey of Canada - Atlantic, Natural Resources Canada*

Government of Canada	Gouvernement du Canada
Fisheries and Oceans Canada	Pêches et Océans Canada
Natural Resources Canada	Ressources naturelles Canada
Environment Canada	Environnement Canada
National Defence	Défense nationale

Dolphins in The Gully area